Concerns for Ungulate Collision Mortality along New Surface Route

Rogers Pass Project

Report

CP Rail
Special Projects

MacLAREN PLANSEARCH
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CONCERNS FOR UNGULATE COLLISION MORTALITY ALONG NEW SURFACE ROUTE

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1.0 OVERVIEW SUMMARY

CP Rail received approval to construct a second track through Glacier National Park, B.C. in December, 1981. Approximately 9 miles (14.5 km) of the project is a surface route through the Beaver Valley. The Federal Environmental Assessment Review Office (FEARO) Panel reviewing the project has registered concern for the potential of increased collision deaths of moose on the new track. The Panel requested that CP Rail study the problem to determine what, if any mitigative measures could be incorporated into the design or operation of the new track to minimize collisions. This report is on studies commissioned by CP Rail to MacLaren Plansearch Corp. to address the potential problem of train/ungulate collisions.

A review of literature was undertaken to identify those features of moose life history which might relate to collisions with trains, and to document the extent and nature of the problem as reported elsewhere. In terms of life history, aspects of feeding ecology, seasonal migratory behaviour, habitat selection, and population dynamics are summarized and discussed. Reports from a variety of sources indicate that moose mortality on railways does occur, and often in significant numbers, but there has been very little research on the subject. The effect of snow was revealed as being a major factor both in the lives of moose and in the relative vulnerability of the animals to transportation-related mortality.

In Glacier National Park snow is perhaps the dominant fact of life, and moose there lead a marginal existence in comparison to many other areas where they occur. Field studies indicated that food plants are abundant but during much of the winter are largely unavailable either because they are covered with snow or because the animals' mobility is restricted to the extent that they can exploit only small areas for long periods. During winter 1982-83 maximum snowpacks at the nearest weather station was about 30%

less than the long-term average, but was still nearly twice the level believed critical for moose. The animals remained "yarded" in small, intensively-used areas until late winter, when the snow had consolidated sufficiently to bear their weight.

The Beaver River Valley appears to be the primary block of moose habitat in Glacier National Park. The animals occupying that area are suspected to be mostly non-migratory, but probably do not exist as a closed population. Surveys indicated that the winter 1982-83 complement consisted of as few as ten animals. That is somewhat below previous estimates, but this is understandable as a minimum of seven mortalities have been documented since October 1981, two apparently dying naturally in the rather severe 1981-82 winter and five being killed by motor vehicles on the Trans Canada Highway.

Although only six railway kills have been documented in the area in the past 20 years, in comparison to 29 on the highway, there is justification for concern that railway kills may increase since the new ROW parallel to the Beaver Valley will be closer to the valley bottom where most of the moose occur. The area of greatest concern is in the vicinity of Mountain Creek, since that is where the railway reaches the valley bottom and it also appears to be the area of most concentrated winter moose activity in the Beaver Valley.

A variety of mitigative actions are suggested to reduce the incidence of railway-moose conflicts. These include management of vegetation on and near the ROW to avoid attracting animals to the track, manipulation of train speed and perhaps scheduling, manipulation of ROW snow cover to facilitate escape by moose which do appear on the track, and provision of packed trails in the Mountain Creek area designed to attract and hold animals away from the ROW. Given the present level of knowledge on local moose movement patterns, and on the relative merits of various mitigative structures such as fences, the use of such structures is not

considered appropriate in the area at this time. It is suggested that institution of a comprehensive train crew reporting system for both local sightings of ungulates as well as for any kills which might occur, would be the single most important contribution CP Rail could make toward solution of the problem at this time.

2.0 INTRODUCTION

For engineering and logistical reasons, roads and railways in northern areas are typically built in lowlands, usually in valley bottoms, where conflicts with wild ungulates which use or cross such areas seasonally may become acute. The problem of transportation-related wildlife mortality (together with its implications for human safety and economic considerations) is well-known in a general sense, but actual documentation and studies to search for solutions and/or to design mitigative measures are much more numerous and complete for highways than for railways (e.g. see reviews and bibliographies in Flygare 1979; Shank 1979; Harrison et al. 1980; and Damas and Smith 1982). In March 1982 CP Rail was granted approval by the Canadian Transport Commission to proceed with their proposed new track and tunnel project through Rogers Pass in Glacier National Park, B.C. (Fig. 1). Initial impact evaluations (LGL 1981) and subsequent reviews by Parks Canada and Canadian Wildlife Service officials have identified a potential conflict between trains and ungulates, particularly moose, on the proposed new rail line. This report is on 1982-83 studies, commissioned by CP Rail to MacLaren Plansearch Corp. to address that problem specifically. The major objectives were:

a) To monitor winter moose distribution and numbers in the Beaver River Valley, as they might relate to location of the new rail line;

b) To assess potential impacts of the new rail line on ungulates in the area; and

c) To recommend measures which might be taken to mitigate the impacts identified.

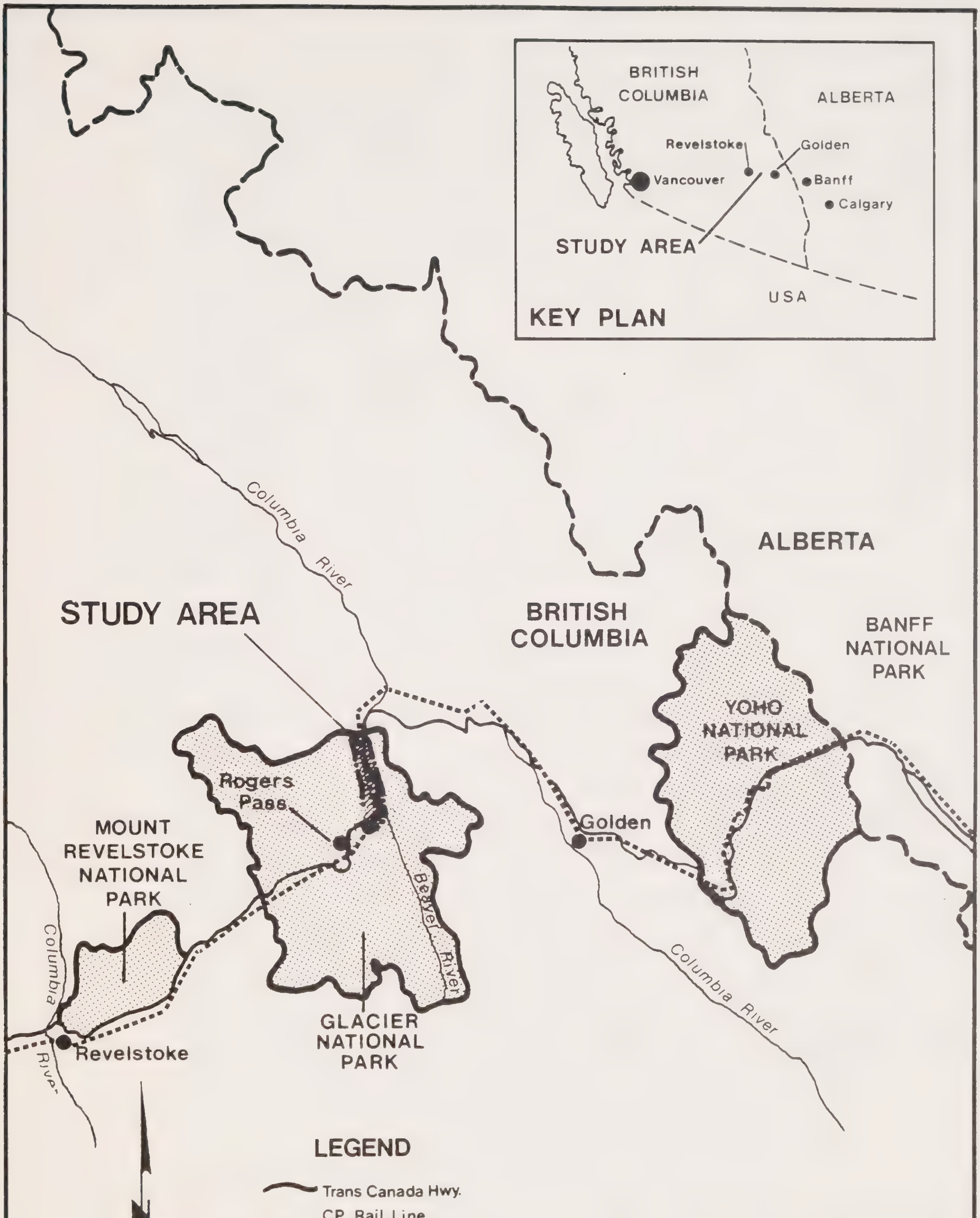

Figure 1

STUDY AREA

3.0 REVIEW OF PERTINENT LITERATURE

To provide perspective for contemplation of the potential moose-train collision hazard on the new rail line in Glacier National Park, the following sections summarize some of the established knowledge on relevant aspects of moose biology and the problems of moose mortality on railways.

3.1 Moose Biology

Of particular interest in the context of this study is consideration of factors, both extrinsic and intrinsic, which influence the local distribution of the animals. It is important to understand why they are where they are at any given time, and to know whether they have any options. In that regard, factors which appear to be worth focussing on are: 1) Snow cover, as it affects mobility and foraging opportunity; 2) Food habits; 3) Seasonal movements and distribution; and 4) population dynamics.

As noted by Eastman (1977), the moose is a highly adaptable animal, occurring in a variety of forested habitats. It is well-suited for life in northern ecosystems, having both physical (Kelsall 1969) and behavioural adaptations for dealing with snow (Edwards and Ritcey 1956; Eastman 1977). Further, it is primarily a browser in an area where trees and shrubs occur as the major available food resource, especially in winter. Another important adaptation of the species in northern areas is the quick and positive response of populations to changes in the forest cover such as may be caused by fire and some types of logging (see Geist 1971a).

3.1.1 Effects of Snow

Despite adaptations, a topic which is almost always addressed in moose studies is the effects of snow. Edwards (1956) related periods of "deep snow winters" to population declines of ungulates, including moose, over large areas of British Columbia and

Alaska. Winter kill is believed to be the primary cause of such declines, however there is evidence that winter severity, particularly in terms of snow depth and duration, may also have negative effects on reproduction (Markgren 1973).

In addition to its effects on abundance, it appears that snow depth is also the primary factor mediating seasonal movements and winter habitat selection. Edwards and Ritcey (1956) documented seasonal movements in Wells Gray Park, B.C. as being in spring, "associated with thaws and decreasing snow depths" and, in winter, a "dynamic" process with "the centre of moose abundance moving downward slowly as snow accumulates throughout the winter". Van Ballenberghe (1977) found that year-to-year variation in the timing and extent of autumn migration was "well correlated with snow depth" and noted that some moose did not leave their summer range in a year of little snow.

Eastman (1977), in a review of several sources, described three snow depth classes in relation to effects on general mobility: 1) Shallow (up to 40 cm) - moose experience little or no hindrance to movement; 2) Medium (41 - 80 cm) - moderate impediment to movement; and 3) Deep (more than 80 cm) - movement difficult. He found that as snow depths approached 80 cm the animals tended to move out of open deciduous areas and into thicker forest where there was higher relative humidity, less wind, more moderate temperatures and about 50% of the snow depth recorded in the open. Snow quality (density, hardness, extent of surface crusting) may sometimes be at least as important as depth (Pruitt 1959; Kelsall 1969), and other observers have noted increasing dependence on coniferous cover induced by changes in snow characteristics (Bergerud and Manual 1969; Mytton and Keith 1981; Addison et al. 1980).

As a rule, winter ranges of radio-collared moose have proved to be smaller than those in summer (Phillips et al. 1973; Addison et al. 1980), and this is probably due largely to the influence of snow. The extreme case occurs in eastern North America where snow conditions are often such that the activity of one or more animals may

be restricted for long periods to small intensively-used areas referred to as "yards". The mean size of 121 yards studied by Proulx and Joyal (1981) in Quebec was 0.44 km^2. They implied that the yards became relatively smaller as snow depths increased, and indicated that this was especially true with a snow accumulation of more than 75 cm. Peterson (1955) referred to involuntarily restricted movement of this kind as "enforced yarding" and thought that its chief cause was "fairly deep, heavily crusted snow which moose break through...".

3.1.2 Food Habits

The moose has been referred to as a generalist herbivore (Belovsky 1978), utilizing a wide variety of plant foods over its range. Results of winter food habits studied for several areas across North America are summarized in Table 1. These results demonstrate the variety of plants consumed by this species, the differences between areas, in one case (Isle Royale) differences within an area between years, and the number of species which may be added to the list under conditions of a light snow cover (Kenai Alaska). Perhaps more importantly, the results show that a few species of deciduous shrubs (willows, birch, aspen and red osier dogwood) and one conifer (balsam fir) are key browse species in most areas.

During summer, i.e. the snow-free season, moose take a much larger variety of foods, including leaves, low shrubs, forbs and aquatic plants. LeResche and Davis (1973) provided a list of non-browse summer foods used by moose in southcentral Alaska, including the leaves of birch (_Betula papyrifera_) and willow (_Salix_ spp.), newly emergent sedges (_Carex_ sp., _Eriophorum_ sp.) and horsetails (_Equisetum_ sp.), fireweed (_Epilobium_) and lupine (_Lupinus_) in pre-flower stages, lowbush cranberry (_Vaccinium vitis-idea_) and various lichens (_Peltigera_ sp. and _Cladonia_ sp.). In Northern British Columbia, Eastman (1977) recorded heavy use in summer of the leaves of Sitka alder (_Alnus crispa_) and occasional use of grasses (_Graminae_) and forbs such as aster (_Aster_ sp.) and Oregon

TABLE 1
WINTER FOODS OF MOOSE IN NORTHERN
NORTH AMERICA, AS REPORTED IN THE LITERATURE

FOOD PLANTS[a]	RANK[b] AMONG WINTER FOODS IN AREAS[c] INDICATED							
	NORTHERN B.C.[1] (14)	N.E. MINNESOTA[2] (12)	WESTERN QUEBEC[3] (12)	ISLE ROYALE[4] (1945) (14)	ISLE ROYALE[4] (1970) (13)	MONTANA[5] (7)	INTERIOR ALASKA[6] (5)	KENAI ALASKA[6] (14)
BALSAM (*Abies lasiocarpa*)	3	4	9	5	1	3	-	-
CEDAR (*Thuja plicata*)	T	-	-	-	-	-	-	-
MAPLE (*Acer glabrum*)	T	9	-	-	-	-	-	-
ALDER (*Alnus crispa*)	T	11	T	11	12	4	4	7
SASKATOON (*Amelanchier alnifolia*)	T	7	12	7	6	-	-	-
BOG BIRCH (*Betula glandulosa*)	T	-	-	-	-	-	-	-
PAPER BIRCH (*Betula papyrifera*)	2	6	10	2	7	-	-	-
RED-OSIER DOGWOOD (*Cornus stolonifera*)	4	5	-	6	3	-	2	1
ASPEN (*Populus tremuloides*)	5	3	3	1	4	T	-	-
COTTONWOOD (*Populus balsamifera*)	T	T	-	-	-	6	3	2
WILLOW (*Salix* sp.)	1	1	1	4	8	-	-	6
MOUNTAIN ASH (*Sorbus* sp.)	T	8	7	3	2	1	1	3
SQUASHBERRY (*Viburnum edule*)	6	-	-	13	13	-	-	-
LUNGWORT (*Lobaria pulmonaria*)	7	-	-	-	-	-	-	-
BEAKED HAZEL (*Corylus cornuta*)	-	2	11	8	5	-	-	-
FIRE CHERRY (*Prunus pennsylvanica*)	-	10	2	9	10	-	-	-
RED MAPLE (*Acer rubrum*)	-	-	4	-	-	-	-	-
MOUNTAIN MAPLE (*Acer spicatum*)	-	-	8	12	11	-	-	-
STRIPED MAPLE (*Alcer pennsylvanicum*)	-	-	5	-	-	-	-	-
(*Viburnum alnifolium*)	-	-	6	-	-	-	-	-
SUGAR MAPLE (*Alcer saccharum*)	-	-	-	9	9	-	-	-
SUMAC (*Rhus* sp.)	-	-	-	14	-	-	-	-
SILVERBERRY (*Eleagnus commutata*)	-	-	-	-	-	-	-	-
CURRANT (*Ribes* sp.)	-	-	-	-	-	2	-	-
SNOWBERRY (*Symphoricarpos albus*)	-	-	-	-	-	5	-	-
SPRUCE (*Picea* sp.)	-	-	-	-	-	7	5	-
CRANBERRY (*Vaccinium vitis-idea*)	-	-	-	-	-	-	-	11
GRASSES (*Gramineae*)	-	-	-	-	-	-	-	4
HORSETAIL (*Equisetum* sp.)	-	-	-	-	-	-	-	5
BEARBERRY (*Arctostaphylos* sp.)	-	-	-	-	-	-	-	8
LABRADOR TEA (*Ledum* sp.)	-	-	-	-	-	-	-	9
ROSE (*Rosa* sp.)	-	-	-	-	-	-	-	10
LARCH (*Larix laricina*)	-	-	-	-	-	-	-	11
CLUBMOSS (*Selaginella* sp.)	-	-	-	-	-	-	-	11

[a]Plants with a frequency of occurrence greater than 1%, by whatever means of assessment (rumen analysis, browse survey, etc.).

[b]Rank in frequency of occurrence, where 1- highest, etc.; the number in parentheses under area names is the total number of species in that area with frequencies over 1%; T- refers to occurrences of 1% or less.

[c]Superscripts by each area refer to following sources and sampling methods: 1- Eastman (1977), rumen analysis and trailing; 2- Peek *et al.* (1976), feeding site examinations; 3- Joyal (1976) browse surveys; 4- Krefting (1974), browse surveys; 5- Knowlton (1959), feeding site examinations; 6- Cushwa and Coady (1976), rumen analysis.

[d]The species listed for alder applies only to the B.C. location; occurrence in other areas involved other or unspecified species.

fairy bells (Disporum oreganum). Aquatic plants most used by moose in central British Columbia (Ritcey and Verbeek 1969) were an emergent horsetail (Equisetum fluviatile), bur-reed (Sparganium sp.), and various pondweeds (Potamogeton sp.).

In Isle Royale National Park, summer feeding on aquatic plants appears to provide virtually the sole annual source of dietary sodium to moose resident on that island (Jordan et al. 1973). Indeed, Belovsky (1981) offered evidence that sodium there is a major limiting factor to growth and maintenance of local populations. Moose have not been so well studied elsewhere, and the extent to which we can expect single-element limitations or effects on populations in other places is not known. However, though emphasis is often placed on winter foods in recognition of the critical nature of that season, several authors have noted the nutrition-deficient characteristics of ungulate winter diets in most areas[1]. In short, most of the real positive inputs to moose growth and maintenance probably come in summer and, as at Isle Royale, "critical" elements in some areas may be ingested only at that time.

3.1.3 Seasonal Movements and Distribution

An important feature of moose biology over most of the species range is seasonal movements, generally between summer and winter range. The extent and nature of these movements vary from area to area, but they are generally along an altitudinal gradient (to "lowlands" for winter and to "uplands" for summer) and, as discussed previously, they appear to be largely related to changes in snow depth as it affects animal mobility and availability of forage. Edwards and Ritcey (1956) felt that the distance between winter and summer range in Wells Gray Park was as much as 65 km for some individuals. Radio-collared animals in the relative flatlands of Ontario (Addison et al. 1980), northwestern Minnesota

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1 See review on this subject in Eastman (1977).

(Phillips et al. 1973) and northern Alberta (Mytton and Keith 1981) mostly migrated less than 20 km between seasonal ranges, while in southcentral Alaska seasonal migrations of up to 110 km were recorded. In all of these areas, however, at least some marked individuals did not migrate at all.

Although moose are dispersed in relatively solitary fashion throughout their range during the snow free season (Franzmann 1978), suitable habitats in winter appear to be limiting in most areas and the animals tend to aggregate in that season (Peek et al. 1974; Eastman 1977 and others). This results in local densities as much as 40 times higher (Edwards and Ritcey 1956) than the approximately 0.5 animals per km^2 which seems to be the average, in summer, for large areas of boreal forest range (Peterson 1955).

However, local winter densities can vary considerably between years, apparently depending mostly upon the snow cover and the degree to which it stimulates movements away from the summer areas.

3.1.4 Population Dynamics

There are numerous factors affecting moose numbers. One of these is the successional state of the habitat. Geist (1971) referred to the shrub communities within forested areas (e.g. along watercourses and in the subalpine zone) as "permanent" moose habitat and the new, secondary successional communities following major disturbance "transient" moose habitats. Although he notes that the permanent habitats are very important in their support of nucleus moose populations between the transient habitats (both spatially and temporarily), he states that the really noticeable (large) populations generally occur on the latter. The quick response and dramatic population increases following burns, for instance, have been well documented (Spencer and Hakala 1964, Alaska; Peek 1974, Minnesota; Edwards 1954, Wells Gray Park, British Columbia). As noted by the above authors and by Geist

(1971a), Eastman (1977) and Irwin (1975), secondary successional growth on such areas eventually proceeds beyond the point of significant forage production and local populations then decrease. In some areas, for example on the Kenai Peninsula in Alaska, an important tool in moose management is interference with the successional cycle by prescribed fire or other mechanical means (Sigman 1979).

Although fire and various forms of land clearing may provide successional habitats of value to moose, clearings can be too large. Moose require forest for various kinds of shelter (Eastman 1977; Thompson and Vukelich 1981; Hamilton et al. 1980; McNicol and Gilbert 1978, 1980), and failure to provide for these needs may result in reduced local carrying capacity regardless of food availability. Clearings may also be detrimental to moose when they are in the wrong places, particularly on winter ranges.

Changes in moose numbers as a result of habitat changes, as discussed above, are usually mediated indirectly through changes in natality (Eastman 1977) and by migration, but may occasionally be a result of mortality from starvation or malnutrition related diseases (see Hatter 1949). Other factors which may affect numbers include: 1) hunting, especially where networks of roads and other developments increase accessibility; 2) losses of calves through accidents or predation; and 3) effects of parasites and diseases. Finally, and appropriately in the context of this report, substantial losses of moose are recorded in some areas as a result of collisions with vehicles on highways and railways. The highway problem has been amply documented and intensively dealt with by Damas and Smith (1982), Flygare (1979), Harrison et al. (1980) and others (see bibliographies in those sources). Railway collisions are the subject of the following section.

3.2 Railroad Collision - Mortality of Wild Ungulates

3.2.1 The Extent of the Problem

In his summary of accidental mortality in moose Peterson (1955) asserts that "collision with trains is a common cause of death". He provides documentation for the statement in the form of reports from several locations in Ontario (up to 12 animals in a week on one section of track), Yoho National Park (20 - 30 per year) and Alaska (up to 200 per year). Rausch (1956) arranged a reporting system between the Alaska Railroad and the U.S. Fish and Wildlife Service, and closely investigated several sections of the 800 km rail line between Anchorage and Fairbanks himself during the winter of 1955-56. From that work he estimated a total minimum kill for that year of 425 - 450 animals. Included in that estimate was documentation of local "hot spots" and times as follows:

- 68% of the total kill occurred between Wasilla and Curry, a distance which constituted only 19% of the total rail line;

- 131 of 225 (58.6%) kills reported by the railroad were from an area in which 219 carcasses were counted in the spring, i.e. the reported kill was at least 40% lower than the actual kill;

- 27 were killed on one 22 km section of track "during and immediately following the December 30, 1955 - January 1, 1956 snow storm"; and

- A total of 54 moose were killed between Goose Creek and Montana Creek (9.6 km), "the majority... during a two week period in February".

In British Columbia, as elsewhere, there has been no consistent reporting system, but there are periods during which someone apparently took a special interest in the problem. Records kept for the CNR line between Red Pass and Prince Rupert for the complete years 1965-1967 revealed total annual (reported?) kills of

330, 223 and 265 animals, respectively. In January and February of 1965, 176 moose were killed between McBride and Prince George, a distance of approximately 200 km (files, B.C. Fish & Wildlife Branch, Prince George). Guiquet (1978) lists a personal communication report of a kill of 598 moose on the Robson-Prince Rupert CNR mainline in the "more severe than normal" winter of 1968 and another of 23 elk killed in a single train accident in the Kicking Horse Valley (Kootenay Region) in 1957. Based on an early June count of carcasses along the CN line after the hard winter of 1975-76, a minimum of 44 moose and 16 deer were killed between Smithers and Houston (about 65 km) in that year. The count was stimulated by the report of a concerned engineer who estimated that no less than 57 moose and 50 deer had actually been hit in that area (Hatler 1979). The preceding author was of the opinion that "in some years, the combined kill of moose and deer from collisions with vehicles and trains probably exceeds the hunter kill for some local herds". The winter of 1981-82 was apparently another bad one for moose kills along railways in northern British Columbia, and in one instance north of McBride a group of about 30 caribou were killed in one or two incidents at the same location over a short period of time (Child pers. comm.). Conservation Officer A. Breitkrutz (pers. comm.) estimated that as many as 25 moose were killed on a 20 km section of track west of Vanderhoof during that winter.

Reports in Damas and Smith (1982) for wildlife collision accidents in Canada's National Parks are oriented to highway incidents, but do include railway statistics as well. They, and other sources, emphasize that kill figures for the railways are less reliable than for highways because of their relative remoteness from areas regularly patrolled by park officials and the travelling public, and because there is no obligation for train crews to report. In short, it appears that more animals are killed on the railways than are reported (more on this later). With that in mind, Table 2 summarizes some reported train kill data for the four parks which Damas and Smith (1982) list as having a rail line within their borders. As shown, train kills represent from about 10 -

30% of the reported transportation-related mortalities during the period studied, with Glacier National Park (GNP) on the low (10%) end of that range. The elk is the species involved most overall among the railway deaths, but only moose were reported killed by trains in all four parks.

In general, the figures of Table 2 average out to about 58 reported railroad kills per year in the four parks, of which about 10% are moose. The average for moose kills per park is 3.2, 1.8, 0.4 and 0.3 for Banff, Jasper, Yoho and Glacier National Parks, respectively. While these figures would seem to be insignificant, they may be misleading in that; a) the actual total kill may be much larger than that reported, b) the 10-year average may mask the importance of a significant local kill in any one year; and c) the kill could be important out of proportion to numbers if for some reason, it was selective for particular sex and age classes or behaviourally important individuals.

3.2.2 The Nature of the Problem

The most thorough analysis to date on the circumstances and mechanics of moose-train collisions is that of Rausch (1956). Focussing on an area where a high rate of kill by trains had been documented, he studied local and seasonal movements and activities of moose on the belief that "understanding...and subsequent control of moose movements is likely to be the key to the problem". He also recorded a series of moose versus train case histories "in an attempt to learn the behaviour patterns of moose facing an on-coming train".

3.2.2.1 Effects of Snow

Rausch (1956) found "a definite correlation... between seasonal fluctuations in snow depths, moose abundance along the tracks, and variations in moose fatalities by dates". He noted that 50% of the reported kill occurred during the last two weeks of February and first week in March, when there was an average of 80 cm of

TABLE 2 Summary[a] of Railway-related Wildlife Mortality in Four Canadian National Parks, 1970-1980

Park	RR Extent[b]	Trans. Cor. Kills[c] Total	Trans. Cor. Kills[c] RR No. (%)	Species killed on Railway: Elk No (%)	Moose No (%)	Deer No (%)	Sheep No (%)	Bears No (%)	Others No (%)
Banff	80 km	1191	273 (23)	222 (81)	32 (12)	10 (4)	--	3(1)	6 (2)
Jasper	75 km	868	255 (29)	98 (38)	18 (7)	25 (10)	92 (36)	14 (5)	8 (3)
Yoho	50 km	294	44 (15)	34 (77)	4 (9)	5 (11)	--	--	1 (3)
Glacier[d]	40 km	71	7 (10)	--	3 (43)	--	--	4 (57)	--
ALL	---	2424	579 (24)	354 (61)	57 (10)	40 (7)	92 (16)	21 (4)	15 (2)

[a] Mostly from Damas and Smith (1982), Volume 2

[b] Length of rail line in the park indicated

[c] Kills by vehicles in transportation corridors

[d] Corrected data from L. Gyug and K. Van Tighem (pers. comm.)

snow in the "critical kill areas", and when "aerial counts of moose within (200 m) of the tracks reached their highest point". Although several of the kill records available to Peterson (1955) were apparently from spring and summer, most other sources have emphasized the role of snow in ungulate railroad mortality. As noted in the previous section, the heaviest kills along the CNR line in northern British Columbia were in the most severe (i.e. deepest snow) winters. Supporting findings from Damas and Smith (1982) are as follows:

Banff National Park

- 76% of reported elk mortalities due to trains was during the period January-March "when snow depth is greatest".

- The winter of 1971-72 had both the highest recorded snowfall...and the greatest number of elk mortalities.

- "Elk are known to travel along the railbed during the winter, particularly during periods of increased snow depths".

- "It...appears that railbeds...are preferred (moose) travel routes in severe winters".

- "In both 1971 and 1972, years with record snow depths, 16 moose fatalities in each year were the highest recorded to date." Note: both highway and railway kills are included in the above figure, but railway>highway in both years (9-7, 12-4, respectively).

Jasper National Park

- "As a high proportion (48%) of sheep railway collisions occur in January and March, it was suspected that snow conditions influence the degree to which sheep utilize the rail corridor."

- "Elk winter railway mortality is considered to be related to snow depth as the two winters of greatest snow cover (71/72 and 73/74) show the most reported mortalities."

- "...as mule deer avoid deep snow... some deer are believed to utilize the railbed as a travel corridor."

- "The two years with the most snow... showed the highest (deer) railway mortalities."

- "Railway mortality data give some indication that the railway is used as a winter travel route (for moose)."

Yoho National Park

- "80% of all recorded railway kills (of elk) occurred from November to March inclusive."

- "Once on the rail-line in winter, the high snow banks may prevent animals from escaping oncoming trains."

3.2.2.2 Distribution of Kills

There is a tendency for railway mortalities to be clumped. Rausch (1956) identified several such "hot spots" along the Alaska Rail-road, and Damas and Smith (1982) documented a similar situation in some of the Canadian National Parks, as follows:

Banff - "Railway mortalities (of moose) tend to be grouped near the Vermilion Lakes and an area west of the Bow River bridge. A slight tendency for kills to be located adjacent to major stream(s)... is noted".

Jasper - "The railway mortalities (all species) are more tightly grouped than the mortalities on the Yellowhead Highway."

Glacier - All of three moose mortalities reported for this park in the period 1970-1980 were in the vicinity of Mountain Creek.

In most cases the observed clumping is believed to be due to the railway passing through sections of habitat to which animals are attracted in winter, and in which they tend to aggregate in that season (e.g. see Peek et al. 1974). Rausch (1956) also notes that often the openings in the forest created by the railroad right-of-way results in production of successional vegetation which attracts the animals. In other cases animals may be trapped between the rails at certain locations by topography (steep banks, cuts, etc.). The reason for the animals being on the grade in such places is explained by Rausch's description of the railroad as "... a common connecting link (between) food patches, edges, burns and river bottoms...". Use of the plowed railroad as a travel route was also described for elk and deer in some of the earlier quotes on snow effects (above) from Damas and Smith (1982).

3.2.2.3 Time of Day as a Factor in Railway Mortalities

Rausch (1956) found that considerably more moose were hit by trains after dark than during daylight hours, apparently even though daytime rail traffic was the heavier. In considering his data, both he and Geist (1963) acknowledged that part of the explanation probably lay in the fact that the animals were more active at night. However, it was the opinion of engineers who Rausch interviewed, and he later confirmed it with some of his own observations, that the moose actually behaved differently in reaction to trains during the different light conditions. During the day the animals were clearly frightened of the train and fled from it from fairly great distances, and often at right angles from the tracks, while at night they often did not attempt to run until the last minute, if at all. Geist (1963) speculated that the night reaction might be a response to the train's headlight beam, comparable to that which may be observed among rabbits on

highways after dark when they "run within the lightbeams, reluctant to enter the dark".

Other than the sources quoted above, there appears to be little written information on the subject. Damas and Smith (1982) reported an early morning and late evening peak in highway kills in Banff National Park, but "estimated" times of railway collisions in Jasper (all species) included 51% during daylight, 33% during crepuscular light conditions and only 16% at night. However, they noted that there may have been some confusion such that "time of reporting" was given rather than "time of accident", thereby biasing the sample toward working hours.

3.2.2.4 Sex and Age Composition of Railway Kills

Examination of specimen material from 230 train-killed moose from southcentral Alaska revealed that no one age or sex group was responsible for the train versus moose problem there, at that time (Rausch 1956). That is, the kills of each class were roughly in proportion to their occurrence in the population studied. The same is true for most species for which there are adequate data in the compilation by Damas and Smith (1982). Two apparent exceptions are mountain sheep and moose in Jasper National Park; in both cases there appears to be a preponderance of males among the railway mortalities. Such a result could be due to a combination of at least temporary segregation of the sexes, with males occupying sections of track or environmental conditions which make them more vulnerable.

3.2.2.5 Behavioural Aspects of Railway Kills

Again, Rausch (1956) is virtually the only literature source. He observed 101 case histories of moose versus train from the cab of a train engine and noted that, while the animals appear "genuinely frightened", they do not exhibit a consistent response in expressing their fear. Attempting to characterize their reaction when confronted by a train, he wrote:

> "The 'average moose', when frightened by a train, usually attempts to leave the tracks. The moose, using his front feet as 'feelers', tests the snow adjacent to the tracks. If he sinks in to his belly and bogs down, he extracts himself, returns to the track, ambles along a few paces and repeats the above process. Generally the moose succeeds in leaving the track on his first or second attempt, but of those cases actually observed, 23 animals, or about 20%, failed and were killed."

Occasionally the reaction of the moose is agonistic in nature. Rausch (1956) described one situation in which a bull moose was believed to have become irritated at the sound of the train's horn and charged it. B.C. Wildlife biologist K. Child (pers. comm.) photographed a similar incident from the air near Prince George in the winter of 1981-82, and has records of animals which successfully avoided collision with trains and then struck at them from the side with their feet as they passed by.

It seems likely that whatever behaviour is elicited by an oncoming train, it comes from the animals predator avoidance repertoire (perhaps particularly after dark). As described by Rausch (1956), the train whistle is almost always used by the train crew to attempt to get animals off the tracks, and under certain circumstances it can be successful. However, of all natural sounds pertinent to moose the whistle of a train probably most closely approximates a wolf howl. Field observations of moose-wolf interactions suggest that those moose which stand their ground may be more successful in avoiding predation than are those which flee (e.g. see Mech 1970). Clearly the same behaviour would <u>not</u> be appropriate for dealing with trains.

The present author has had numerous discussions with train crews on the subject of moose-train collisions, and has twice observed moose successfully avoiding collisions. In both cases, animals were safely out of the way in plenty of time but, as described by Rausch, returned to the track as the train approached more

closely. It seemed apparent in each case that the animal hoped to outrun the threat bearing down upon it, but "understood" that it could not do so in the deep snow and therefore sought the firm footing on the plowed railbed (see Photos 1 and 2).

3.2.2.6 Effects on Populations

As pointed out previously, it is generally thought that actual data on wildlife mortality due to collisions with trains are minimal due to reporting problems. From the accounts in Damas and Smith (1982) it is apparent that in most cases too little is known of the "living" populations to enable interpretation of even the best mortality data in terms of their significance to population trends. One clear exception is the apparent effect of combined highway and railway mortality on declining bighorn sheep populations in Jasper National Park (see Van Tighem 1981). Damas and Smith (1982) have provided estimates of "transportation impacts" on populations of various species in the Canadian National Parks in terms of their suspected ability to compensate for losses. Their two most severe levels of impact, "significant" and "contributary" are defined as transportation mortality exceeding 50% or 25-49%, respectively, of the population's estimated (not measured) annual productivity. In these terms, the following species, in parks with railways, fit into those impact categories as listed below:

Banff National Park

Significant - elk, one local "population" of mule deer, two sheep herds and one local population of moose (Bow Valley).

Jasper National Park

Significant - seven sheep herds considered either in this category or contributary; also one local herd each of elk and moose.

Photo 1. Two moose on plowed BCR railbed north of Fort St. James, B.C., as observed from the cab of an approaching engine. Note, from the tracks that the animals had been travelling between the rails.

Photo 2. The same two moose as the train draws nearer. The relative difficulty of movement of the animal off the tracks is evident, and is illustrative of why the plowed tracks tend to be used as travel routes by moose. The second animal narrowly escaped being hit when it lost confidence in its ability to escape when it hit the soft snow and tried to return to the firm footing between the rails.

Yoho National Park

Significant - elk, park-wide.
Contributary - mule deer, park- wide.

Glacier National Park

Significant - mountain goat, Mount Tupper.
Contributary - moose, northern portion of park.

It should be emphasized that the above designations are for all transportation mortality. In most cases, both highway and railway kills are implicated although the "significant" mortality of mountain goats in Glacier Park involves only highway incidents. The "contributary" designation for moose in that park is due primarily to small population size rather than high mortality.

Dealing with moose specifically, previous sections have described extent of movements to lowland winter ranges and tendency to aggregate on these ranges. Therefore the potential for serious impact on a local population, which may be dispersed over a much larger area during the rest of the year, is certainly greatest at that time. Further, the lowlands used in winter are also often the locations chosen for transportation corridors.

3.2.3 Summary, Extent and Nature of the Problem

Preceeding sections have demonstrated that railway collision mortality of large wild ungulates, including moose, does occur. In some areas and at some times, especially during severe snow conditions, large numbers of animals can be lost in a relatively short time. In some cases this may also have serious implications for the railway involved. Rausch (1956) described one ride during his Alaska Railroad studies during which "in addition to killing eight moose, the train was three hours late...", and another in which a collision with a moose caused "an expensive derailment". A more dramatic example is provided by a front-page article in the

Prince George Citizen ("Moose, trains play deadly game" January 28, 1974), which describes collisions with moose resulting in three CNR derailments, involving 25 cars, all in a three-day period.

The problem is clearly very real, but for some reason has received only minimal attention from wildlife managers and researchers to date. This is evident in the relative paucity of printed information referred to above. In the very complete literature review by Shank (1979) on factors relating to "disturbance" of large mammals, only 12 of 551 references deal to any extent on railway-wildlife relationships and only 4 of the 12 are specific enough in approach to include the word "railway" or "railroad" in the title. Recently in British Columbia the biological staff in the B.C. Fish and Wildlife Branch office at Prince George has been attempting to mobilize for moose-railway research (K. Child pers. comm). and the B.C. Wildlife Federation, a citizen's group, has submitted a research proposal and recommendations to the provincial Minister of Environment (W.G. Hazelwood pers. comm).

4.0 MOOSE AND THE RAILWAY IN GLACIER NATIONAL PARK, B.C.

The following sections deal specifically with observations and subsequent interpretations from field studies conducted in Glacier Park during 1982-83, particularly as they relate both to the background information presented above and to the proposed new rail line along the Beaver Valley.

4.1 Methods

Field work devoted specifically to the ungulate collision studies included both aerial and ground surveys conducted on monthly trips to the area during the period December-April 1983. Aerial surveys, all by Bell 206 Helicopter flown by the same pilot and each about 2 1/2 hours in duration, were designed to cover both the newly cleared right-of-way (ROW) and the Beaver River low-lands. Flights along the ROW commenced at the approximate location of the east portal for the proposed short tunnel and were flown at low elevation (50 - 60 m above ground) and slow speed (80 - 100 kph) to the junction with the existing rail line near the Rogers Pass "Pusher Station". All wildlife and sign detectable from the air was noted and, in the case of ungulate tracks, an attempt was made to look for the individual(s) responsible and to determine the origin and destination of movements, particularly in relation to the new ROW.

The return flight south along the Beaver Valley consisted of a tight zig-zag pattern back and forth between the Trans Canada Highway (TCH) and the base of the west slope of the Beaver Valley below the TCH bridge across the river, and between the TCH and the base of the valley's east slope above that point. The survey was terminated opposite the proposed location for the west portal of the short tunnel.

As with the flight along the ROW, observations of all wildlife and sign were recorded both verbally on a small tape recorder and by a map reference number on a photomosaic of the project area. Nevertheless, the species of primary interest was the moose and the valley surveys were intended primarily as moose census flights in the absolute sense, i.e. with "total count" as the ideal. Accordingly, all areas potentially attractive to moose and in which they might be most readily seen, i.e. areas of deciduous and/or low coniferous cover, were searched most intensively. Whenever moose tracks were found in an area, that area was searched until: a) the animal(s) responsible had been seen; b) tracks were judged "old" and animals considered no longer present; or c) animal(s) believed present but judged unlikely to be seen despite continued effort. In the last case, the number of animals assumed present was one unless there was obvious evidence to the contrary. Whenever it could be accomplished without undue harassment of individuals, animals seen were classified as to age (adult or young-of-the-year) and sex. Sex identification was on the basis of whatever characteristics were most practical under the circumstances including presence/absence of antlers or, in one case, antler scars, presence/absence of calves, and presence/ absence of a white vulval patch (Mitchell 1970).

Ground surveys complemented the aerial work in various ways. All vantage points from the TCH and various access roads within the study area were regularly exploited for opportunities to observe moose in areas where tracks had been seen from the air. In several cases such tracks were investigated directly by observers on showshoes to confirm identification and/or relative "freshness" and, in a few cases, to ascertain whether adjacent areas of moose activity involved more than one animal. Finally, snow tracking along accessible sections of the ROW was also used to determine the extent and nature of winter use of that area by animals other than moose (See Appendix 6). As with the aerial work, it was recognized that all wildlife sightings are of interest in the

framework of park natural history descriptions and interpretation and no observation of vertebrates or their sign went unrecorded. Observations of animals other than moose are presented herewith as Appendices 7 and 8, and will not be dealt with further in this report.

The field activities described above were conducted on the following days:

Aerial Surveys - 6 December, 12 January, 19 February, 15 March, and 27 April.

Ground Studies - 6 - 8 December, 12 - 13 January, 18 - 20 February, 15 - 16 March, and 26 - 28 April.

Other sources of information contained in this report include published scientific literature, unpublished government and consultant reports, interviews and correspondence with local authorities and supplementary field observations, particularly those pertaining to moose, obtained during other recent biological field studies in the Beaver Valley area. Applicable activities from those projects include helicopter and ground surveys similar to those described above, but conducted between 20 - 23 April, 1982 (MacLaren Plansearch 1982), a detailed study of vegetation along the proposed ROW preclearing (18 - 21 June, 1982 - see MacLaren Plansearch 1983a) and helicopter and ground observations relating to beaver occupation of aquatic environments in the Beaver Valley, November 1982 (MacLaren Plansearch 1983b).

4.2 Results

4.2.1 Population Numbers and Composition

Moose apparently did not establish in the area until the early 1930's, and they have never been studied intensively in Glacier

National Park (Van Tighem et al. 1982). No regular censuses are undertaken, and the current park population is not well known (L. Gyug, pers. comm). Based apparently upon estimates from park wardens, Damas and Smith (1982) listed a park population figure of "approximately 20 animals", but a footnote indicated that 11 had been seen "during a flight over the Beaver/Mountain Creek area" in 1980. It is not clear whether the footnote was intended to indicate that the previous estimate was too high or was just offered as supplementary information. Meanwhile, the estimate of 20 for the park included a secondary estimate of "about 12" for the study area of this report, i.e. the lower Beaver River Valley area. During the Initial Environmental Evaluation (IEE) studies (LGL 1981), two wildlife surveys were conducted in the area. On 19 January 1980 a total of nine animals were seen, all between Stoney Creek and the north park boundary; a flight on 25 February tallied only three animals, all north of East Gate, and two additional animals (a cow/calf pair) were seen from the ground just north of East Gate a few days later.

It should be emphasized that moose are difficult to census and the relationship between numbers seen and numbers actually present can vary considerably, depending upon the animals' use of coniferous cover, their activity patterns, and numerous observer factors (see Caughley 1974; Novak and Gardner 1975; Gasaway et al. 1982). In a series of experimental counts of known numbers of moose in large enclosures in Alaska, LeResche and Rausch (1974) found that the most experienced observers under the most ideal conditions saw only 68% of the moose present.

Table 3 summarizes results of the 1982-83 Beaver Valley moose surveys in terms of numbers of animals seen and accounted for along various sections of the essentially linear study area. Not having marked animals, it was necessary to interpret each individual sighting in relation to all sightings over the entire study period. Appendix 1 presents the nature and rationale for such

TABLE 3 - Numbers and distribution of moose seen or otherwise accounted for on field trips to the Beaver River Valley area, Glacier National Park, British Columbia, April 1982 and Winter 1982-83.

	Number of Animals Indicated by Survey Period																							
	April 82				December 82				January 83				February 83				March 83				April 83			
Location	F	G	T	M	F	G	T	M	F	G	T	M	F	G	T	M	F	G	T	M	F	G	T	M
N. of Park	-	2	1	2	-	-	-	-	2	-	1	2	2	-	2	2	-	-	2	2	-	-	1	1
101-150	-	-	1	-	1	-	1	2	1	-	2	1	2	2	1	3	2	-	2	3	-	-	2	1
151-200	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-	2	-	2	-	-	-	-
201-250	2	-	-	2	-	-	-	-	-	-	-	-	2	-	1	2	1	-	1	1	-	-	-	-
251-300	2	-	-	2	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	2	2
301-350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
351-400	-	-	-	-	-	-	1	1	-	-	2	1	-	-	-	-	-	-	1	1	-	-	-	-
401-450	-	2	2	2	2	-	1	2	1	-	1	1	-	-	1	1	-	-	-	-	-	-	-	-
451-500	-	-	-	-	-	1	-	1	-	-	2	1	-	-	1	1	-	1	2	1	-	-	-	-
500 +	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	2	1
TOTAL	5	4	4	9	3	1	3	6	5	-	11	8	6	2	7	10	3	3	8	10	-	1	7	5

[a]Location references are survey stake numbers along new ROW, as shown on photomosaics of the area. The area from stakes 0-100 are north of the park, while the others indicate sections of the Beaver Valley to the south of the north boundary, as delineated by lines running approximately east and west through the stakes indicated.

[b]Numbers given are for F (number of animals seen on flight), G (number of different animals, i.e., those not seen on the flight, which were seen from the ground, T (number of areas in which tracks seen, either from the air or the ground, but no animals seen, and M (minimum number of moose represented by the combination of F, G and T. Note that these are not strictly additive since in some cases tracks were judged to have been "probably attributable" to animals seen elsewhere.

[c]Data for April 1982 from MacLaren Plansearch (1982).

interpretations which were based largely upon sex and age classification of a few individuals during that portion of the winter when movement was most restricted. The basic data for this population estimation exercise are contained in the individual flight reports (Appendix 2) and in a summary of ground observations pertaining to moose in the area (Appendix 3). Locations of sightings are shown in Figure 2.

As shown in Table 3, the largest number of moose seen on any one flight was six (February) and the largest number accounted for by both aerial and ground observations was 10 (both February and March). In the synthesis of these data (Appendix 1), the minimum number known present in the Beaver Valley in winter 1982-83 is ten, one prime male, one small male, five females older than one year and three young-of-the-year. No obvious yearlings were seen, thus most or all of the previous year's production may have been lost. There is some evidence that the winter of 1981-82 was severe and at least slight decline of the local population is suggested. Although a maximum estimate of 13-15 is possible for the winter 1982-83 Beaver Valley animals, there is no strong evidence in favour of expanding the estimate beyond ten, the number actually documented present (above).

During the course of studies, a minimum of five other animals were documented in locations remote from the Beaver Valley study area. This included a cow/calf pair west of Rogers Pass, an unclassified adult in the extreme upper Beaver area, and two animals (probably a cow/calf pair) which spent the winter on a slide well up Mountain Creek (see Appendix 1). The relationship of these animals to those in the lower Beaver River is not known, but their existence suggests that the Beaver group is not a closed population.

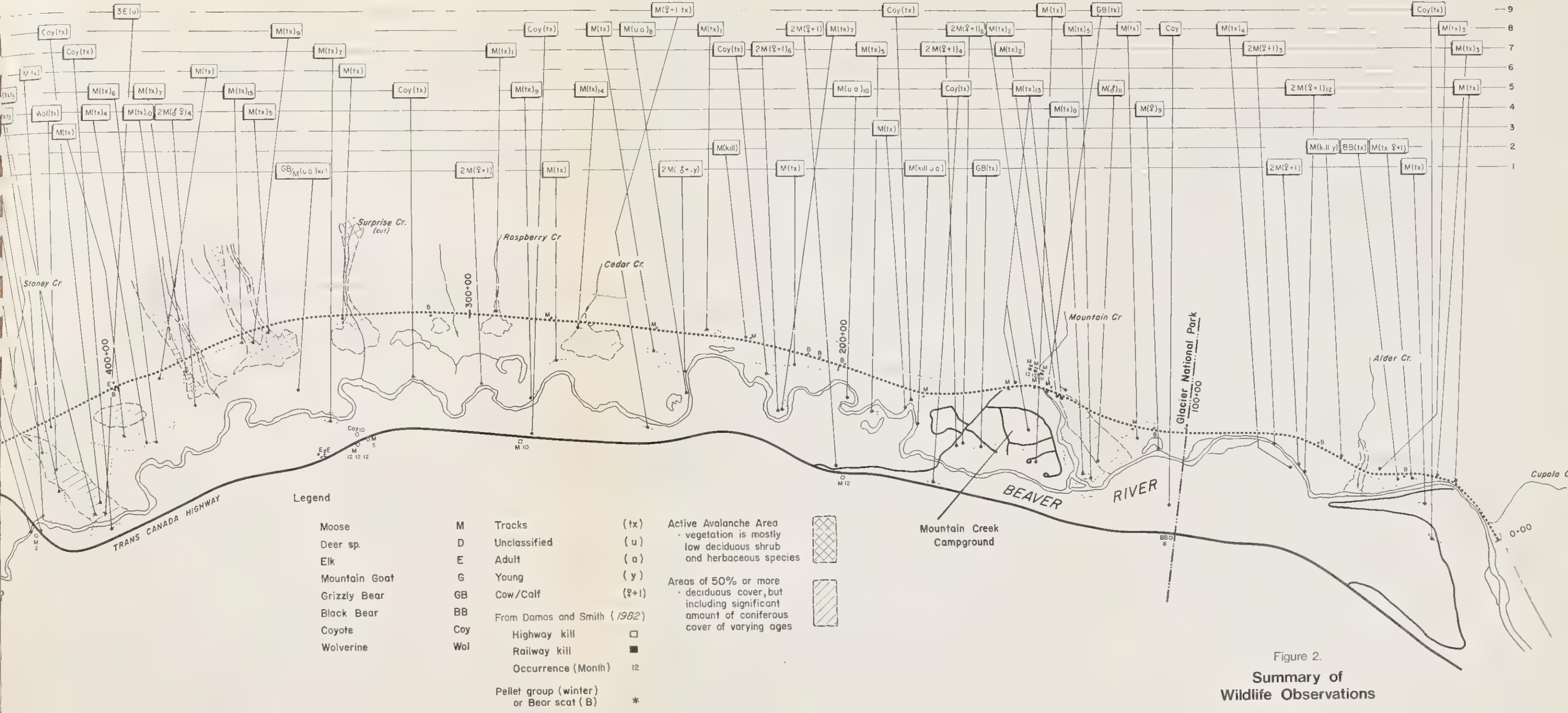


Figure 2.

Summary of Wildlife Observations

4.2.2 Ecology of Moose in the Beaver Valley

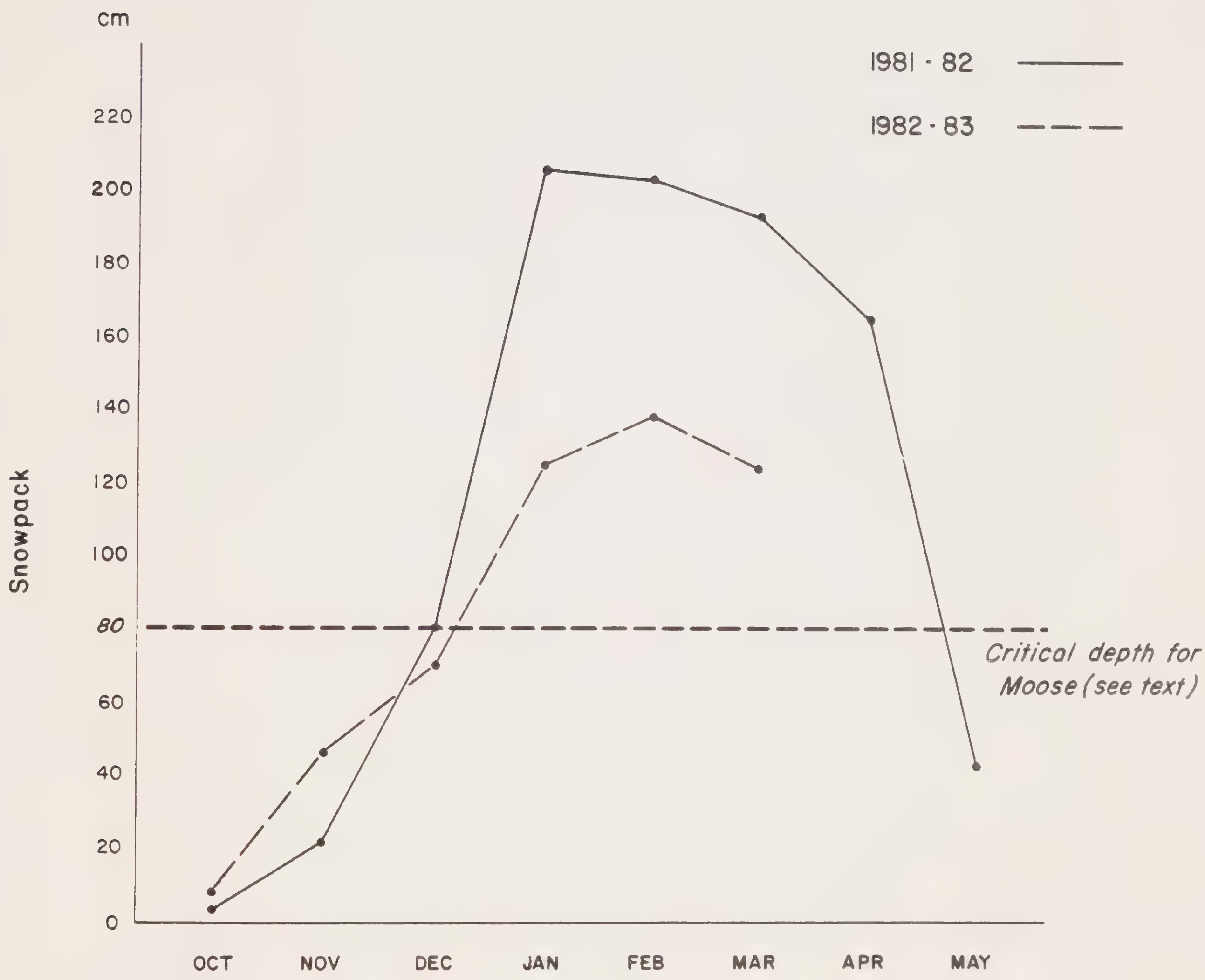
Description of the local ecology of a species can only be accomplished by detailed observations over several annual cycles. Following paragraphs are to touch on some of the more important aspects of life history, as they might be related to the problem of railway mortality. The basic outline for this section is the literature review on moose biology given earlier (Section 2.1).

4.2.2.1 Effects of Snow

A brochure on the climate of Glacier and Mount Revelstoke National Parks (Parks Canada 1980) continually emphasizes the heavy snowfall in the area. It describes the influence of that snowfall on glaciers, avalanches and the "Interior wet belt" forest, and notes that "deep snows and steep terrain severely limit... large mammal populations".

Appendix 9 lists temperature and precipitation data comparisons for the Glacier weather Station (Rogers Pass) over three periods: 1) 30-year averages (1941-1970), termed "normals", 2) October through April 1981-82, and 3) October through March 1982-83. It appears that 1981-82 was somewhat colder than normal and significant snowfall started later than usual but was much heavier than normal, especially in January and February. Recall that two apparently winter-killed moose were found in the Beaver Valley following that winter. The winter of 1982-83 was warmer than normal and, except in January considerably less snow fell. Despite considerably more field time in the area during that winter, no evidence of dead moose was found.

The differences in snow accumulation between 1981-82 and 1982-83 show dramatically in Figure 3. There was relatively little snow in 1982-83 and it diminished much more quickly. Yet, it is apparent that even in this relatively mild year the peak accumula-



Source : Monthly data for 1981-82 and 1982-83 from Atmospheric Environment Service (Environment Canada), Vancouver, B.C.

Figure 3.

Snowpack at Glacier Weather Station

ROGERS PASS

tion was almost twice the level considered to seriously hinder moose mobility (see also Section 3.1.1). Even though snowfall is probably less in the Beaver Valley than in Rogers Pass where the data of Figure 3 originate, it is apparent that snow is an exceedingly important factor in the lives of moose there, a fact also emphasized by Van Tighem et al. (1982). Observation of tracks in January and February indicated that in some cases moose were literally swimming in the snow rather than walking through it, since they were not touching bottom in their tracks before being "high-centered" on their bodies.

Repeated observations of some individuals, e.g. the bull north of the TCH bridge, the cow/calf pair at the Mountain Creek campground, and the animals farther up Mountain Creek indicated that local movement was restricted for weeks, if not months (see Appendices 1 - 3). The wintering situation for moose in the Beaver Valley is not "aggregation" on winter range but "enforced yarding" as described in Section 3.1.1. Additional evidence for this is the heavy utilization of all edible browse and barking of cedars in some of the intensive use areas (yards) observed, and the use of the open river as a travel route (Appendices 2 and 3). Both the cedar barking and the water travel have also been observed during an ongoing B.C. Hydro sponsored moose study in the Big Bend area of the Columbia drainage (R. Bonar pers. comm.). Additional comments on snow and its effects will also be applicable in following sections.

4.2.2.2 Food Considerations

Evidence was found of moose using most of the plant species listed among their major food habits for other areas (Table 1), especially willow, red osier dogwood and saplings of poplar. Many preferred species are covered by snow during the winter, including much of the red osier dogwood, and some examples of very close utilization of the few stems that were sticking up were noted (see

Appendix 3). During ground studies of vegetation along the surveyed ROW, preclearing (MacLaren Plansearch 1983a), it was noted that red osier dogwood, willows and other preferred species were very abundant along drainage gullies south of Mountain Creek, but at the level of the proposed ROW utilization was almost nil. Much more use of all browse species was noted from Mountain Creek north and in all beaver systems and river-side locations visited in the Beaver Valley. The overall impression gained is that food is abundant and a much larger summer population could be supported. However, problems of availability arise rather quickly in the winter and local feeding opportunity is limited at that time.

4.2.2.3 Seasonal Movements and Distribution

No certain conclusions can be drawn from studies to date, but it is likely that many of the moose which wintered in the Beaver Valley had not moved far from their summer range. Most of the studies cited in Section 3.1.3 which involved radio-collared animals found that a proportion of the animals followed were non-migratory. In the Beaver Valley a variety of factors, virtually all man-caused, have probably conspired to select against migration in that area. For example, a) the lower Beaver Valley, which was probably used more as a summer range than as a wintering area when moose first arrived in the area, is virtually surrounded by transportation corridors; b) the area which was probably once the ultimate winter range (the Columbia Valley at the mouth of the Beaver) has been flooded, and c) some of the more topographically gentle lower side valleys (e.g. Cupola Creek), have been heavily logged off and/or made unduly accessible to man.

Appendix 4, a listing of observations of moose sign along the new ROW prior to clearing, indicates that the majority of evidence (distribution of winter fecal pellets, potential browse species and incidence of browsing, and summer sign) indicates little use of the west slope of the Hermit Range above the Beaver Valley and

relatively heavy use of the Beaver Valley at and below Mountain Creek. Other observations given earlier, e.g. the winter locations of at least seven of the ten moose identified in the area (Appendix 1), the location of highway kills in 1982-83, and the locations of the only known railway kills in the area (Figure 2), all point to the lower Beaver Valley in the vicinity of Mountain Creek as being the area of most concentrated moose activity in the study area. Our observations and records examined by Van Tighem et al. (1982) indicate that the Mountain Creek section of the valley is also the area most heavily used by cow-calf pairs.

This raises the question of whether Mountain Creek itself is an important migration area, i.e. whether moose regularly move up Mountain Creek to summer ranges and back down to the Beaver Valley for winter. We consider it unlikely that many animals do so. The Mountain Creek Valley above the existing trestle is precipitous and lacking in forage for several kilometres of its length, and the creek bottom itself is too boulder strewn to offer easy passage. No trail is evident along either side of the creek in that area. The combination of cover, browse opportunity and perhaps even more moderate weather from Mountain Creek campground at least down the Beaver to Cupola Creek (and probably farther) is the primary attraction.

In short, most directional seasonal movements in the Beaver Valley are probably parallel rather than perpendicular to the river itself.

4.2.3 Railroad Collisions in the Beaver Valley

As noted in previous sections, only 3 moose kills are known to have occurred on the existing rail line adjacent to the Beaver Valley since at least 1970 and all were in early winter (November-1, December-2, see Figure 2) near Mountain Creek. The new rail line, being lower downslope and therefore closer to the primary

moose activity in the valley, will have the potential for more frequent conflicts with moose than on the existing line, and especially in the relatively high use area between the Mountain Creek campground and the north boundary.

Although the animals made little use of the newly cleared corridor in winter 1982-83, the combination of easy access at Mountain Creek and a plowed railbed offering easy going will invite increased use when the new line becomes operational. The animals now move relatively little during much of the winter only because, under normal circumstances, they cannot. They will if the opportunity presents itself.

4.2.4 Potential Impacts on the Population

As suggested earlier, the degree to which the moose observed in the Beaver Valley constitute a closed population is not known. Casual observations detected a minimum of five moose in areas adjacent to the study area, 50% of the number documented by intensive effort within the study area, so the chances for recruitment from elsewhere exist. Nevertheless, it is clear that snow conditions constitute the critical factor in moose biology in this area and those animals existing in small pockets of habitat elsewhere may be more vulnerable to winter mortality than those in the rich beaver-modified riparian habitats in the Beaver Valley. Further the outlying moose may be very sedentary, rarely moving from even marginally favourable areas. Finally, from a national park perspective, the Beaver Valley "population" is of considerable importance because of its accessibility to the viewing public.

There is little choice, under existing circumstances, but to treat the moose in the Beaver Valley as though they do exist in a closed population situation, accepting any recruitment or emigration from elsewhere as a "bonus". Gyug and Van Tighem (1982) provided a table of all reported transportation-related mortality of moose

between 1962 and April 1982, showing a total of 33 (27 highway and 6 railway). The addition of two highway-killed male calves to that list in the fall of that year raises the total to 35 (see Appendix 1). Although the "average" is less than two per year, the concern must be directed to what might happen in any one year. A minimum of seven animals (two "natural", five highway) died in the Beaver Valley area between October 1981 and December 1982 (Appendix 1); clearly the present population of possibly only 10, perhaps as many as 15, could not long sustain such mortality, even at maximum reproduction. More importantly, loss of key individuals, for example the two bulls identified in the study area in winter 1982-83, could reduce or temporarily arrest local recruitment.

Since the emphasis on consideration of the railway problem is usually on direct mortality, it should be mentioned here that other impacts are possible. Reports from discussions with train crews elsewhere (Hatler, unpubl.) indicate that occasionally moose run long distances (up to 5 or 6 km) ahead of slow-moving trains or speeder cars, and eventually get off the tracks "uninjured". Such animals may die directly as a result of the exertion and associated physiological stress (see Geist 1971b), or may at least be weakened to a point of greater vulnerability to die from other causes. This is particularly true under the conditions of marginal or negative energy budgets which characterize the over-wintering period in most areas.

To ensure the continued viability of the Beaver Valley sub-population of moose, it appears that it will be essential to both reduce the present rate of highway mortality and prevent excessive increase of direct or indirect railway mortality. Following pages address only the latter although available evidence suggests that it alone cannot be enough. The highway problem is by far the greater and is probably increasing with increased traffic flow (see Damas and Smith 1982).

5.0 MITIGATION MEASURES

Appendix 5 is a copy of recommendations, together with their rationale, made by Rausch (1956) for reducing direct kill of moose by trains in Alaska. Those recommendations, including a) reduction of train traffic during hours of darkness, b) manipulation of headlights and horn, c) reduction of train speed in critical areas and d) manipulation of snow berms, as well as other methods he and others have considered will be discussed in terms of their appropriateness in the context of the Beaver Valley area.

5.1 Reporting by Train Crews

Mitigation of a particular problem is not possible without a clear understanding of that problem. Damas and Smith (1982) described the need to study the dynamics of animal/vehicle collisions in terms of the interactions between the common components of such accidents, namely the vehicle and its driver, the animal and its behaviour, and highway design. For railways only the studies of Rausch (1956) have focussed on the problem in that manner, yet the railway/wildlife collision situation should be far easier to come to grips with than is that on the highways. There are fewer variables in train traffic than in that pertaining to highways, and there are far fewer train crews than there are drivers of motor vehicles. As a group, train crew members should be far easier to identify and approach and therefore more accessible to brief either on procedures and standards for reporting or, if they were available, on precautionary measures which might be undertaken to reduce the incidence of wildlife collisions.

Damas and Smith (1982) noted in most of their discussions of railway-caused wildlife mortality in Canadian national parks that kill figures were minimal because of "under-reporting", that is, train crews were not reporting all animals hit and park/wildlife officials were not themselves becoming aware of such kills because of the remoteness of some of the rail line areas. There seems to be a general feeling that this situation exists in Glacier

National Park, but it is not clear if that feeling exists because the reported kill is less than is expected or because it is less than is known.

There would appear to be little future in pursuing "we-do/you-do-not" arguments in the context of this report. Whatever the past and existing situation regarding reporting, it is clear that this will be the initially most important ingredient of successfully mitigating the potential collision problem on the new ROW. The importance of an intensive and comprehensive reporting system for railway kills has been emphasized before (Hardy and Associates 1981). It is clear that the seasonal and local movement patterns of wildlife in the area are inadequately understood, and train crews in the area should be instructed to report as follows:

- All ungulate and large carnivore sightings within 100 m of the rail line, from the Pusher Station to Cougar Creek, with the following minimum information: Date, time of day, location (RR milepost plus whether east or west of track), weather, species, sex and age if known, activity, if known and reaction to the train. A check-off type of data form and/or radio-communication to someone with such a form would facilitate such reporting.

- All ungulate and large carnivore collisions (same data as above, and probably on the same form).

All reporting instructions should apply to both eastbound and westbound traffic. Someone at CPR should be made responsible for ensuring that collision reports are transmitted to park/wildlife authorities within one day, regardless of whether or not the animal was killed; the same person should accumulate sighting records and submit them to parks/wildlife officials once monthly.

All kills should be investigated on the ground to determine sex, age (by appropriate biological collections, e.g. teeth), conditions and, by back-tracking, origin and nature of the animals movements prior to being killed.

Analysis of data may identify migration corridors, feeding areas or other contributing factors which can be corrected by mitigating structures or activities. Note that the above reporting system is recommended to include a section of the rail line outside the park. The rationale for this is that animals occupying that area are almost certainly part of park populations.

5.2 Mitigative Actions

5.2.1 Vegetation of ROW

Care should be taken to ensure that vegetation attractive to wildlife, especially winter browse species for ungulates (deciduous shrubs, cedar and yew), does not recolonize the ROW and its edges.

5.2.2 Vegetation Adjacent to ROW

For the slide and creek bottom crossings south of Mountain Creek as identified in Figure 4, consideration should be given to an annual fall program of removing potential browse for a distance of at least 25 m beyond the ROW edge both up and downslope. All movements recorded on these areas in the winter 1982-83 were meandering-type feeding movements rather than obviously directional "migratory" movements, and absence of food may discourage travel to the ROW in these areas where such travel is most likely. Summer observations, as discussed earlier, suggest that the forage loss by such action in those locations would not be significant to the animals.

5.2.3 Manipulation of Train Size and Speed

Rausch (1956) found that mortality of moose from train collisions was considerably lower on an area in which topography required slow speed, despite higher local moose densities. Hardy and Associates (1981) predicted potentially greater wildlife collision

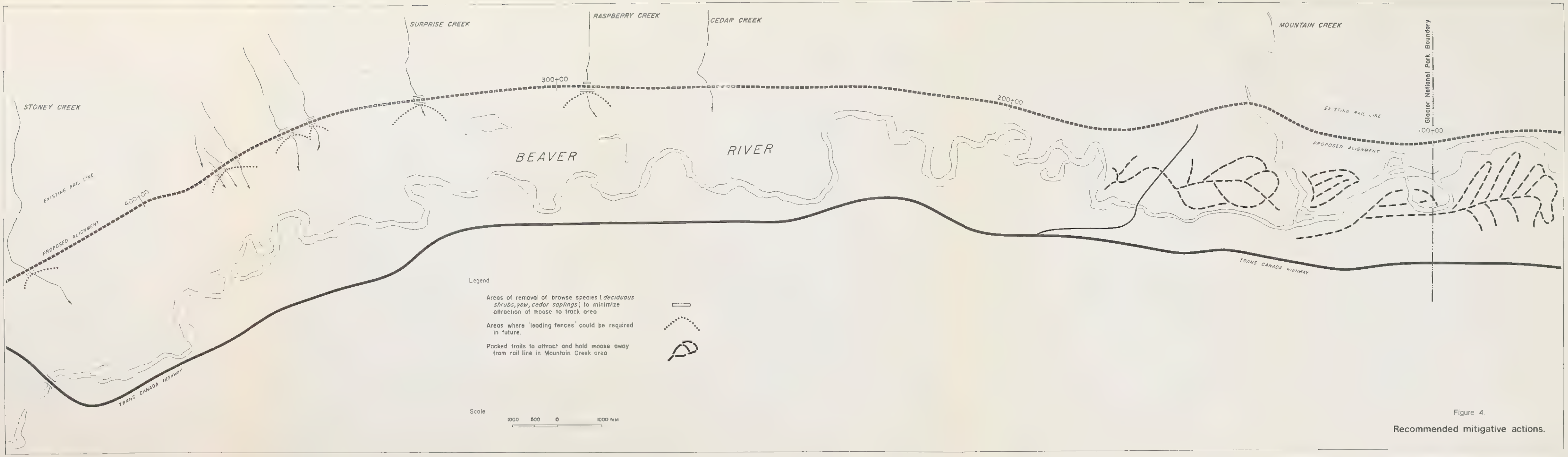


Figure 4.

Recommended mitigative actions.

problems on the twinned tracks system in Jasper National Park as a result of both increased traffic and speed. Council et al. (1973), in considering environmental aspects of an arctic railway, proposed "long, heavy trains" to reduce both speed and the number of trains per day. It seems evident that train speed is an important factor and consideration should be given to controlling it during the planning of operations on the new twinned system in Glacier National Park. Rausch's (1956) findings indicated that speeds of less than 30 mph saved moose from potential collisions. Speed controls should apply to both rail lines since they are relatively close together from about Mountain Creek north, where the potential collision problem is greatest.

5.2.4 Manipulation of Train Schedules

Rausch's (1956) work indicated that the greatest collision mortality occurred during the hours of darkness. Realizing that there are other factors to consider in scheduling trains, it is nevertheless recommended that consideration for wildlife be a part of the scheduling process, and that where the other factors don't seriously conflict, trains be routed through the park area in daylight hours to the extent possible.

5.2.5 Manipulation of Horns and Headlights

Rausch (1956) noted that under deep snow conditions, timing the horn blast to ensure the animal was not frightened off the track too soon could be an important device for saving moose (see Appendix 5). He also reported that the headlight may have been a factor in confusing moose encountered at night. Although subsequent experiments were apparently inconclusive (Rausch 1958), it is recommended that train crews be consulted for their advice on such matters. It may be that some individuals have devised train or warning control procedures which are effective or seem promising.

5.2.6 Snow Removal

Many of the reports cited earlier and discussions with train crews indicate that often moose could be saved if they were not thwarted in their escape efforts by berms of snow along the grade. Rausch (1956) recommends spreading of the snow berm immediately after plowing, and as soon as possible after a large snowfall.

5.2.7 Encouraging Use of Areas Away from the Track

As reported previously, the area of greatest concern are those sections of the rail corridors in the vicinity of and downstream from Mountain Creek. Animals tend to follow the path of least resistance in their daily travels and will avoid travel through deep snow where there is a suitable alternative. It is recommended that a series of trails be maintained in the vicinity of Mountain Creek campground and points downstream, as shown in Figure 4. The use of snowmobiles or some small tracked vehicle is recommended, to pack rather than clear the snow (Hardy and Associates 1981). Such trails should not be permanent, so that different forage patches can be exploited in different years or, if warranted, in different months.

Care should be taken to keep the trail system from connecting with the winter yards of animals farther upstream, to minimize the problem of attracting and concentrating animals in the area. Accordingly, it is probably not advisable to begin this operation until the snowpack at Mountain Creek approaches 80 cm.

Care should also be taken to prevent the trail system from connecting with plowed access routes to either the railway or the highway. This may be accomplished with local corral structures, large snow berms, or by topographic features, as appropriate.

5.2.8 Monitoring of the ROW

A regular part of track maintenance and inspection duties should be monitoring of wildlife along the ROW. Reports such as those recommended for train crews would be appropriate. Reports from track crews may also help alert train crews to potential problems before being confronted by them, and thereby enabling them to employ appropriate avoidance measures.

Track crews may also be used to frighten animals away from the tracks; information from the reporting system suggested earlier may demonstrate that at certain times (e.g. rut, early winter before deep snow accumulation, late winter after snow consolidation) may require and justify, regular morning and/or evening patrols.

5.3 Mitigative Structures

5.3.1 Bridges and Underpasses

It is understood that the bridge structure over Mountain Creek is to incorporate an "underpass" arrangement to enable animal movement along that drainage. Although such movement has not been confirmed on any major scale, some probably does occur.

Design of the bridge structure should take into consideration the factors discussed by Damas and Smith (1982, Volume 1, Section 5.4). Such structures are not considered necessary for any of the drainage crossings southwest of Mountain Creek.

5.3.2 Fences

Damas and Smith (1982), Flygare (1979), Harrison et al. (1980) and a variety of sources cited by them have concluded that the use of physical barriers is the only measure which successfully prevents ungulates from entering highway rights-of-way, and applications along the rail line are also possible in this regard. However, as

pointed out by LeResche (1972), construction of barriers along moose migration routes "could have far wider effects on moose than previously expected.".

A continuous fence along the proposed rail line is not recommended. At this stage of knowledge, the reporting system suggested earlier (Section 5.1) would likely produce more valuable results, indicating whether, where and when movement upslope from the Beaver Valley occurs. Such knowledge could then be applied to construct: a) underpasses, in the unlikely event that regularly used migration routes perpendicular to the rail line were located or b) short "leading-fences" in areas where occasional or regular moose feeding activity brought them near the rail line.

Such fences will possibly be required in the vicinity of the new Mountain Creek bridge and for perhaps as much as 1 km in either direction from that point, and at some of the slide and drainage gully areas farther south along the line. Figure 4 depicts the theoretical location and rough lay-out for these fences, which would be designed to gently lead an animal back downslope to areas where vegetation characteristics would not be likely to encourage them to move back upslope upon coming to the end. For example, a V-shaped fence line with its apex near the top of a deciduous slide area would be slanted downhill in both directions until the ends were 25 m or more into unpalatable (hemlock/spruce) cover or open understory.

It is recommended that CPR commit themselves to the reporting system, and to later consideration of mitigation structures which the reporting system indicates are required, but that they do not commit to undertaking any fencing or associated structures without the additional information on animal use of the area.

Also, since the large majority of transportation-related moose mortality in the Mountain Creek area occurs on the Trans Canada Highway, it should be understood that mitigation structures on the railway alone in that area are unwarranted.

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APPENDICES

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APPENDIX 1

ASPECTS OF NUMBERS, COMPOSITION AND DISTRIBUTION OF MOOSE IN GLACIER NATIONAL PARK, BRITISH COLUMBIA, AS DETERMINED BY A SYNTHESIS OF FIELD DATA GATHERED IN 1982 AND 1983.

NOTE: In the absence of marked animals, the following analysis uses two primary methods to distinguish between individual moose in the park. The first considers sex and age classification of the animals actually seen, and the second considers locations of animals and/or sign, especially where such locations are clearly isolated from others, for example two adjacent areas of recent activity not connected by tracks.

MINIMUM KNOWN COMPOSITION

Mature males - only a single individual of this classification was identified, that above the TCH bridge on 8 December (see Appendix 3). In following paragraphs that male will be referred to as animal "A".

Immature males - One small-antlered individual, probably a 2-year old, seen north of Stoney Creek on 6 December, and here considered animal "B". Another small-antlered male, seen just north of Mountain Creek on 12 January, is tentatively labelled "C" here, but there is no certainty that it was not, in fact, animal B.

Adult females - (older than young-of-the-year) - two, "D" and "E", were seen together (clearly without calves) just south of the TCH bridge on a beaver pond survey flight, 3 November, 1983 (N. Trenholme pers. comm.). A minimum of three cow/calf pairs was also present, this being the number seen on the flight of 19 February. They include one pair north of the park boundary ("F"), one at the Mountain Creek campground ("G") and the last ("H") about 2.5 km upriver from Mountain Creek.

The above individuals represent the minimum number known present in the Beaver Valley area in winter 1982-83, i.e. two males, five females and three calves = ten animals. There was no evidence to indicate the presence of any cow/calf pairs in addition to those seen in that area, but there was some difficulty interpreting the

situation re single adults. Following are area-specific sightings over the survey period as they related to the above "known" individuals.

Distribution

1) Connaught Creek to Trans Canada Highway (TCH) Bridge

Animals A, D, and E were originally identified in this section. At least one animal was continuously present during the study period. Two additional sightings of single bulls are almost certainly referable to animal A.

An adult female, emaciated and in scruffy, light-coloured pelage was seen just 50 m above the TCH bridge on 12 January. She could have been either D or E, but cannot be certainly identified as either. No moose of that description was seen in later flights, but because tracks seen subsequently may be referable to this animal, the letter "I" is hereby applied.

Summary - one adult male continuously present, and one adult female present for at least a short time.

2) TCH Bridge to Stoney Creek Area

One dark female seen with small male (B) on 6 December. She also could be either D or E, above. An unclassified animal which spent at least several weeks in the woods south of the new Stoney Creek access road is also potentially either D or E, and therefore may also be the animal identified as I. Tracks in that area in February were from a single animal, and there was some evidence that it was in fact, a female (see Appendix 3).

Summary - two or more animals present in the early part of the winter, but only one staying and that probably one of two females without calves known present in the Beaver Valley.

3) Stoney Creek - Surprise Creek

No animals seen there, but at least one present in December, January and March. The other female of the D/E pair is implicated in the absence of any other information.

Summary - possibly one solitary adult female.

4) Surprise Creek - Cedar Creek

There was little use of this entire section in winter 1982-83. Tracks seen there in January and February are likely referable to cow/calf pair H.

Summary - one cow and calf during part of the winter.

5) Cedar Creek to Mountain Creek

Cow/calf pairs G and H present for most of the winter. A single adult seen 2 km north of Mountain Creek in January could have been the mother of pair H; thick cover in the area may have prevented our seeing the calf on that occasion. The cow/calf pair seen walking on the snow crust just south of the Mountain Creek campground on 16 March was also probably pair H. Pair G was seen on three occasions (twice in February and once in March) near the Mountain Creek bridge and, from tracks, they occupied that immediate area for many weeks.

At least one single animal was also present in the area at least occasionally; its tracks were seen along the new ROW and on the extreme north edge of the campsite area. It was most likely the single animal (C) discussed in the following area.

Summary - one cow/calf pair present most of the winter and another shared with the previous section; possible also one single adult shared occasionally with the next section to the north.

6) Mountain Creek to Park Boundary

At least one set of single tracks continuously present, and believed all referable to small bull C which, as noted earlier, is likely also animal B. An antlerless adult seen just inside the park boundary on 6 December might have been the mother of one of the two cow/calf pairs (F and G) present in the area. Surrounding cover was sufficient to have enabled the calf to remain hidden.

Summary - probably only one animal, a small bull, continuously present.

Park Boundary to Pusher Station

At least one cow/calf pair (F) present most of the winter. No other evidence.

Summary - cow and calf.

ANALYSIS

The 1980 estimate for the Beaver Valley "population" was "about 12 animals" (Damas and Smith 1982). A census flight by LGL (1981) in January 1980 tallied five single animals and two pairs (possibly cows with calves, but not specified). The next survey in the area was apparently that in April 1982 (MacLaren Plansearch 1982), when nine live and two dead moose were accounted for. The live animals included one adult male, two unclassified adults and three cow/calf pairs. The two dead ones were both unclassified adults, and both apparently succumbed naturally (either winter kill or predation). There had also been three kills on the TCH before the April survey, two adult females in the Mountain Creek area, 18 October and 26 December 1981, and one short-yearling female in the same area on 25 March, 1982 (Hammond pers. comm.). Thus, the number of calves known to be remaining in April 1982 (3) was insufficient to balance the documented mortality (5) for the previous fall-winter period.

Only two additional mortalities, both on the TCH, have been recorded after the parturition period of 1982, a male calf in the Mountain Creek area on 8 August and another near the "Beaver Burn" (south of East Gate) on 27 November (Hammond pers. comm.). Hence, a minimum of five calves are known to have been produced in the Beaver Valley in spring 1982, a fact consistent with the earlier estimate of a minimum of five adult females in the area.

In short, little evidence exists in support of expanding the winter 1982-83 Beaver Valley population estimate beyond 10, the number known present. There may, in fact, have been two small bulls rather than one, and there were possibly one or two yearling females, i.e., animals which did not give birth in 1982, although none of the females seen were recognized as yearlings. Mortality and recruitment comparisons from the previous years, and the fact that 1981-82 appears to have been a hard winter, are consistent

with an at least slight decline in the area; a minimum local population of ten and a maximum of 13 - 15 is indicated.

In terms of distribution it should be noted that the large bull consistently occupied the portion of the study area farthest up the Beaver Valley, while the cows with calves were all on the lower (northern) end.

Outliers

At least five other moose were known present in the general Glacier Park area:

1) The tracks of a single adult were followed from the lower end of Butters Creek down the headwaters area of the Beaver River for about 15 km; at that point they went into heavy timber upslope (east) toward Caribou Peak (6 December 1982). That animal was not believed to have come as far downriver as the study area in winter 1982-83.

2) Tracks were seen on a South-facing slide area about 10 km up Mountain Creek from the existing trestle on 6 December and again on the same slide on 27 April. The pilot reported that he had seen two animals there on about 15 April (probably a cow/calf pair). They were clearly there all winter.

3) Tracks of a cow/calf pair were seen beside the TCH about 9 km west of Rogers Pass (Illecillewaet drainage). They had come down from a slide in that area.

The relationship of such animals to the Beaver Valley "population" is unknown, but the appearance of calves in these remote areas, suggests that there are also more bulls than were documented in the Beaver Valley.

APPENDIX 2

FLIGHT REPORTS FOR HELICOPTER SURVEYS
IN THE BEAVER RIVER VALLEY AREA OF
GLACIER NATIONAL PARK, BRITISH COLUMBIA,
WINTER 1982-83

Date: 6 December 1982 Time: 11:35 -

Location: Beaver River Valley and vicinity, Glacier Nat. Park, B. C.

Weather: Clear, calm, cold

Aircraft: Bell 206 Pilot: B. Wilson Observers: Hatler & Trenholme

Species Key: M = Moose, C = Caribou, G = Goat, SS = Stone Sheep, DS = Dall Sheep, D = Mule Deer, GB = Grizzly Bear, BB = Black Bear, W = Wolf, O = Other (specified in remarks)

Classification: M = Male F = Female Y = Young of the Year U = Unclassified

LOCATION	REMARKS	SPECIES	M	F	Y	U
Total Flight itinerary: Revelstoke-head of Beaver River via Butters Creek--down Beaver Valley to Pusher Station--up Mountain Creek to high bog area--along R.O.W. to Rogers Pass--back to Revelstoke along highway.						
Butters Creek-Upper Beaver River	Ungulate trail down lower Butters Creek to headwaters lake on Beaver (at park boundary), then downriver to a point opposite Caribou Peak it went into heavy spruce/fir timber (investigated on the ground on 7 Dec., it proved to be a moose track.)	M				
Avalanche Creek area	Pilot saw three elk here, near mouth of creek, about 2 months ago; he says that is the lowest down the Beaver that he has seen them.	elk				
East Portal	No other ungulate tracks from Caribou Peak to this point.					
Downriver	Map Reference (MR) 1: Beaver haul out and tracks among willow patch, upstream from Beaver Pit.					
Beaver Pit area	Tracks of small mustelid along river upstream from bridge; possibly mink.					
	Old moose tracks in this area (MR-2)	M				
" " "	MR-3: Fresh moose tracks down-stream from bridge.	M				
N. of Stoney Crk.	MR-4: tracks throughout Stoney Crk. fan and these two moose just north, below first major avalanche track. Male small antlered (2 yr old?)	M	1	1		
Surprise Crk. area	MR-5: Fresh moose tracks on decid. covered fan; these within 100m of new R.O.W., but didn't go all the way up to it.	M				

LOCATION	REMARKS	SPECIES	M	F	Y	U
East Gate area	MR-6: Much ungulate activity (tracks) here; pilot said it was horses, but this not confirmed.					
Above Mountain Crk.	MR-7: Beaver haul-out and trails in willows.					
Mountain Crk.	MR-8: Fresh moose tracks all over confluence area (Mountain Crk. and Beaver River.	M				
Park Boundary	MR-9: Antlerless moose, almost certainly female, bedded down at edge of river just upstream from boundary.	M		1?		
Up Mountain Creek	No tracks of any kind seen along creek from RR bridge to a mile or so beyond the forks; one fresh track seen on south-facing alder slide about 5 km below the forks.	M				
Mountain Creek	Two Clark's Nutcrackers along new R.O.W. just south of M. Crk. bridge					
Stoney Crk. area	No tracks along R.O.W. larger than showshoe hare until first avalanche track N. of Stoney Crk. Moose crossed both R.O.W. 's in this area, and traveled along the new one about 100 m (probably the two moose of MR-4; this MR-10.					
Stoney Creek	No goat tracks seen in the vicinity of the trestle.					

No other observations on way home; end of flight.

Date: 12 January 1983 Time: 11:00 -

Location: Beaver River Valley and vicinity, Glacier Nat. Park, B. C.

Weather: 90% overcast, frequent fog patches, occasional rain, 4°C.

Aircraft: Bell 206 Pilot: B. Wilson Observers: Hatler & Trenholme

Species Key: M = Moose, C = Caribou, G = Goat, SS = Stone Sheep, DS = Dall Sheep, D = Mule Deer, GB = Grizzly Bear, BB = Black Bear, W = Wolf, O = Other (specified in remarks)

Classification: M = Male F = Female Y = Young of the Year U = Unclassified

LOCATION	REMARKS	SPECIES	M	F	Y	U
Itinerary: Revelstoke to Beaver River Valley and return, via Rogers' Pass.						
Depart Revelstoke	Pilot reports that it snowed 30-40 cm on 9th and 10th; that new accumulation plus the warm weather, with rain, have resulted in severe avalanche hazard. Park Warden Turnbull recommends no walking on the RR grades in the avalanche areas.					
E. Portal to Beaver Pit Bridge	No large tracks along river; one marten track seen in that stretch.					
Below bridge	Beaver haul-out and tracks among willows about .5 km downstream.					
W. of River	Map Reference (MR) 1: Fresh tracks in heavy timber at edge of beaver meadow; no animal seen but one must be present here.	M				
Downstream	MR-2: more beaver haul-outs.					
Highway Bridge	MR-3: Set of old moose tracks about 1 km upstream.	M				
Highway Bridge	MR-4: Cow moose on gravel bar just above bridge; she looked very thin, and was aggressive toward the helicopter. Same general area: weasel track and track of large mustelid (wolverine?)	M		1		
Stoney Creek fan	MR-5: fresh tracks across lower end of fan.	M				
N. of above	MR-6: older moose tracks; there are no tracks in the meadow area we walked through in December.	M				

LOCATION	REMARKS	SPECIES	M	F	Y	U
N. of Stoney Crk.	MR-7: fresh tracks in swamp below and on avalanche track almost up to new R.O.W.; this first avalanche track N. of Stoney Crk.	M				
Surprise Crk.	No more fresh tracks except marten from MR-7 to Surprise Crk.					
East Gate	MR-8: Fresh tracks, probably coyote, along river in this area.					
N. of East Gate	MR-9: fresh moose tracks along the river.	M				
S. of Mountain Crk.	MR-10: Unclassified adult moose bedded down in thick brush along river; many tracks along river and on ice in this area.	M				1
Mountain Creek	MR-11: Small antlered male bedded down in small opening N. of Mountain Creek; many tracks along lower 1 km of creek and all through campsite area.	M	1			
M. Creek Campsite	One Clark's Nutcracker seen.					
N. of Park boundary	MR-12: cow and calf along river; many tracks here and all the way down to pusher station area.	M		1	1	
Pusher Station area	One Northern Dipper along river; 10+ Common Ravens in dump area.					
Back along new R.O.W.	Occasional marten and hare crossing from Cupola Crk.; old moose tracks near Mountain Creek crossing (MR-13). Animal crossed new R.O.W. 2-3 times and followed it a short distance, but never went as high as old R.O.W.	M				
To Surprise Crk.	A few more marten and hare tracks, but most appear old; probably there is a crust and small tracks are not now registering.					
Cedar Crk.area	MR-14: Moose tracks in timber just 50-75 m below new R.O.W.; the animals appeared to be exploiting small patches of deciduous tree areas (aspen), and just traveling through the conifers.	M				
Between Surprise and Stoney Creeks	MR-15: Bottom end of avalanche track--fresh tracks just below R.O.W. (100m) across the slide area.	M				

LOCATION	REMARKS	SPECIES	M	F	Y
Stoney Creek	Tracks from above moose lead almost to Stoney Crk., in timber all the way; may still be in there.	M			
S. of Stoney Creek	Marten tracks; no other ungulate tracks on remainder of cleared R.O.W.				
Deteriorating weather; end of flight.					

FLIGHT FORM

File ____________

Date: 19 February 1983 Time: 13:20 -

Location: Beaver River Valley and vicinity, Glacier Nat. Park, B.C.

Weather: High overcast, broken to the blue; good light, warm, calm.

Aircraft: Bell 206 Pilot: B. Wilson Observers: Hatler, Trenholme and Phil Hammond

Species Key: M = Moose, C = Caribou, G = Goat, SS = Stone Sheep, DS = Dall Sheep, D = Mule Deer, GB = Grizzly Bear, BB = Black Bear, W = Wolf, O = Other (specified in remarks)

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LOCATION	REMARKS	SPECIES	M	F	Y	U
Rogers Pass	Picked up at Rogers; Revelstoke was fogged in all morning, so we did not get as early a start as we would have preferred.					
Beaver Valley	Flying slowly along new R.O.W.; there is a snowmobile trail along the entire length, made by Parks Canada on wildlife and snow surveys a week to 10 days ago.					
Up to Surprise Crk.	Snow appears to be very hard packed and small tracks are apparently not registering; only one snowshoe hare track seen so far.					
Raspberry Creek area	Old moose tracks; Hammond says that the tracks were fresh on the Parks survey, and that the animal had bedded down on the new R.O.W.; it should be noted that the frequent human tracks from the snowmobile trail out to the edges of the cleared area make interpretation difficult. The old tracks given map reference (MR) #1 on flight map.	M				
Mountain Creek	No more old tracks and no fresh sign down to M. Creek; it has snowed sufficiently since last flight so that our snowshoe tracks are no longer evident.					
	There are fresh tracks just N. of the creek, below the new R.O.W.; the animal was apparently feeding in the area for several days, but it did not cross the R.O.W.; this M.R. 2.	M				
Park Boundary	No more tracks to boundary.					
Pusher Station	Numerous tracks in woods upstream from P. Station bridge, including some near the junction of the new with the old R.O.W.; M.R. 3.	M				

LOCATION	REMARKS	SPECIES	M	F	Y	U
	The remainder of the flight will be along the Beaver Valley proper, in a back-and-forth pattern across the valley.					
Above Pusher Station	Cow and calf standing in the open water of the river, on the first big bend upstream (M.R. 3 also, since these are probably the animals which made the tracks in the woods nearby).	M		1	1	
Mountain Creek	No animals seen in association with the tracks N. of the creek, but it is apparent that one is present--probably the small bull seen here on the 12 January flight.	M				
Beaver River	The river is open over most of its length in this area, and it appears that animals have walked in the shallows at river edge in several places, apparently in preference to plowing through the deep snow remaining in the woods. There is a section (Mountain Crk. confluence up to bridge) which is still frozen over, but there is no evidence of recent moose use on that section.					
Mountain Crk. Campground	Cow and calf seen yesterday are still here; they have moved less than 75 m; M.R. 4.	M		1	1	
Upstream	No fresh tracks up to first bend above campground, suggesting that the cow/calf pair there are concentrating activity there. There is a concentration of old tracks (snow-filled) on the next bend and since they appear isolated from the next ones downstream, are given a reference number (M.R. 5).	M				
Upstream 200 m	Another cow and calf near river (M.R. 6); they are probably the authors of the tracks listed for M.R. 5, and additional tracks in this area including some up towards the new R.O.W.	M		1	1	
East Gate area	Tracks along the river; there are no fresh moose tracks in this area now.	coyote				

LOCATION	REMARKS	SPECIES	M	F	Y	U
W. of East Gate	Numerous tracks along river, on both sides; no certain fresh tracks seen but there are no obvious tracks leading either in or out of the area; there is possibly a moose present here (M.R. 7).	M				
Stoney Creek area	Tracks, apparently fresh, near new Stoney Creek access road; possibly a moose present in the timber here (M.R. 8).	M				
Above TCH bridge	Beaver haul-outs at several locations up to Beaver Pit bridge	beaver				
Beaver Pit Bridge	Tracks, some apparently fresh, at several locations downstream from the bridge, especially on the east side, but tracks also present in beaver meadows and swamps up toward the highway. Probably one animal present (the bull seen in December?). There is also a possibility that the tracks at Stoney Creek (M.R. 8, above) were made by the animal here (M.R. 9); that possibility will be investigated from the ground.	M				

End of flight: no other animals or sign seen.

Summary: 6 moose seen (3 cows with calves), and 4-5 others indicated by tracks.

Date: 15 March 1983 Time: 0910 -

Location: Beaver River Valley and vicinity, Glacier National Park, B.C.

Weather: 50% overcast, high cloud, bright

Aircraft: Bell 206 Pilot: B. Wilson Observers: Hatler & Trenholme

Species Key: M = Moose, C = Caribou, G = Goat, SS = Stone Sheep, DS = Dall Sheep, D = Mule Deer, GB = Grizzly Bear, BB = Black Bear, W = Wolf, O = Other (specified in remarks)

Classification: M = Male F = Female Y = Young of the Year U = Unclassified

LOCATION	REMARKS	SPECIES	M	F	Y	U
Depart Revelstoke	Pilot says that it snowed "heavily" at Rogers Pass yesterday; there is new snow on trees down to about 3500' in Illecillewaet valley.					
New R.O.W.	Flight plan is to follow new line to Pusher Station, then return in usual zig-zag pattern along Beaver Valley proper.					
Stoney Creek area	The snowmobile trail along the R.O.W. is still showing faintly; the only wildlife tracks seen up to this point from beginning of cleared line were one snowshoe hare crossing.	s.hare				
Stoney Creek Trestle	Side trip upslope to see if goats are in the trestle area this year; no tracks seen.					
Surprise Crk. area	No tracks except human to this point; unident. woodpecker flew across R.O.W. just south of creek.					
W. of Cedar Creek	Fresh tracks on new R.O.W. in two places (up and down?) and in woods above line almost up to existing rail line (Map Reference 1).	M				
	Marten tracks crossing there too.	marten				
Mountain Creek	Fresh tracks on grade (new R.O.W.) near bridge (M.R. 2)	M				
Alder Creek area	Many tracks in woods along R.O.W. between A. Creek and Pusher Stn. bridge (M.R. 3).	M				
S. of Pusher Station	Fresh tracks both sides of river at first bend upstream from bridge (M.R. 4); no animals seen.	M				
	Beaver haul-outs in same area	beaver				

LOCATION	REMARKS	SPECIES	M	F	Y	U
Mountain Creek	Many fresh tracks both sides of river just below confluence with Beaver (M.R. 5); no animals seen, but there must be one here--probably the small bull seen there previously. This animal also moved up N. side of Mountain Creek almost up to new R.O.W.	M				
M. Creek Campground	Cow and calf bedded down on trail near main road into campground; many tracks in this area and the animals are not far from where they were seen on 18 and 19 Feb. (this flight M.R. 6).	M		1	1	
Upstream	Fresh tracks still present where we saw a cow and calf last time, but no animals seen this time (M.R. 7).	M				
Beaver Swamp below Cedar Creek	One adult bedded down near river; no others seen, but brush thick and we were lucky to see the one. This could be the female of the cow/calf pair seen in the general area in Feb; many tracks along the river and into the beaver swamp in this area (M.R. 8).	M				1
general	It appears that the animals are much more mobile than earlier in the winter, and there are now continuous tracks from Mountain Creek to at least Raspberry Crk.; this makes it difficult to separate individuals by tracks alone.					
S. of Surprise Crk.	Fresh tracks in slide area (M.R. 9); these extended upslope a ways, but not all the way to the new R.O.W.	M				
Stoney Creek	No fresh tracks in this area this time.					
Upstream from TCH bridge	Many fresh tracks in beaver swamp below the highway in this area; possibly two animals present, but none seen (M.R. 10).	M				
	Much beaver activity upstream from the highway bridge.	beaver				
End of Survey						

Summary: Moose are apparently more mobile now, and appear to be seeking conifer cover; only 3 seen and minimum of 5 more accounted for by tracks. Note: coyote tracks recorded at East Gate, Stoney Creek fan and Beaver Pit area.

Date: 27 April 1983 Time: 0810 -

Location: Beaver River Valley and vicinity, Glacier National Park, B. C.

Weather: Clear, calm, cool

Aircraft: Bell 206 Pilot: B. Wilson Observers: Hatler & Trenholme

Species Key: M = Moose SS = Stone Sheep GB = Grizzly Bear O = Other
C = Caribou DS = Dall Sheep BB = Black Bear (specified in
G = Goat D = Mule Deer W = Wolf remarks)

Classification: M = Male F = Female Y = Young of the Year U = Unclassified

LOCATION	REMARKS	SPECIES	M	F	Y	U
from Revelstoke						
Between MRNP and GNP	One adult, seen over logging slash area.	goshawk				
New C.P. Right-of-way	East portal to Mountain Creek; no wildlife tracks seen along R.O.W.; snow cover is discontinuous and now covering less than 50% of the line, so tracks would not show from the air in many places; sections of the R.O.W. have sloughed away at many of the drainage gullies.					
Mountain Creek	Flew about 10 km up the M. Crk. valley; the lower few km would not be attractive to moose, having little forage, steep sidehills and a creek bottom strewn with large boulders. In short, it seems unlikely that it is a regularly used "migration" route; there is still much snow in the valley and on the slide areas and tracks were seen in only one location, a slide on which we also saw tracks in December. The pilot reports having seen two animals bedded down there about two weeks ago (cow and calf?).	M				
Mountain Crk. crossing	Tracks seen N. of bridge not positively ident. from the air, but later found to be grizzly.	GB				
Beaver River, to mouth	Flew down the river to the mouth. The area from the Pusher Station down to the RR crossing over the Beaver appears to offer as much potential for moose wintering as the area from Mountain Creek to the Pusher Station; however, from there down the valley bottom offers little to attract moose and the flooded area of the Columbia Valley offers nothing.					

LOCATION	REMARKS	SPECIES	M	F	Y	U
Beaver Valley, above Pusher Station	There is still a lot of snow in the thick woods, although there are open areas, especially at the bases of the larger trees.					
East Park boundary	One Canada Goose seen just downriver from the boundary.	goose				
Mountain Creek campground	Still much snow, but no obvious tracks except on the main road in. One pair of goldeneye (sp.) on river just upstream from M. Crk. bridge.	M goldeneye				
Upriver	Another pair of goldeneyes, on an oxbow pond N. of East Gate.	goldeneye				
East Gate area	No obviously fresh tracks seen yet. One pair of Canada Geese and one pair of Mallards seen on beaver ponds across river from E. Gate.	waterfowl				
Between Surprise and Stoney Creeks	One single goose, one pair and one pair of Mallards, on ponds below slide area.	waterfowl				
Stoney Creek	There are moose tracks on the river bars in this area, but they appear old.	M				
Above TCH bridge over Beaver River	One pair of Canada Geese just up the river. 8-10 Mountain Bluebirds seen in Beaver swamp area between river and highway; also, one Great Blue Heron and a pair of unident. shorebirds seen there.	goose birds				
Above Beaver Pit bridge	Fresh moose tracks on river bar; Pair of Green-winged Teal on slough. MR-1	M teal				

End of Survey. Summary: No moose seen and only one set of certainly fresh tracks seen--that above the Beaver Pit bridge.

APPENDIX 3

GROUND OBSERVATIONS OF MOOSE AND SIGN,
GLACIER NATIONAL PARK AND VICINITY,
BRITISH COLUMBIA, ON MACLAREN PLANSEARCH
FIELD TRIPS, WINTER 1982-83

8 December 1982

A. Mature bull moose (antler spread about 100 cm) seen bedded down in a beaver meadow about 3 - 4 km above the TCH bridge. This one was not seen on the aerial survey, although its presence was recorded on the basis of fresh tracks in the area.

B. Stoney Creek Area: tracks seen on the new ROW north of Stoney Creek and in the fan area were investigated. It was confirmed that two moose had worked their way up a slide area from the Beaver Valley, had crossed the new ROW and continued upslope to a point about 25 m above the existing rail line, then had moved back downhill, traveled south along the new ROW for about 50 m, then had returned to the valley bottom. The two moose seen near the base of that slide area on the flight of 6 December were almost certainly the animals involved.

It was also apparent that at least two moose, possibly three, had wandered over much of the Stoney Creek fan area, especially along the creek, the river, and in the deciduous shrub area to the north. Again the same two moose are suspected as having made most of the tracks.

C. The train crew at the Pusher Station were visited briefly as they were having lunch, and were asked about seeing wildlife along the active rail line. Of about 15 men present, most had not seen any. One reported seeing a moose "at milepost 75" (Stoney Creek area) about two weeks previous, and there had been one sighting each of wolverine and marten (no locations given).

13 January 1983

D. Both observers snowshoed in along the Mountain Creek campground access road. One carried on to the new ROW and proceeded north along it to the Mountain Creek crossing, then down Mountain Creek to

the Beaver River and back along the river to the road. The other explored the campground and forested area south of the access road, then moved up to the new ROW and back along it to the point of intersection with the first observer's tracks.

At least one moose had frequented the whole Mountain Creek area, and had browsed on many deciduous shrubs, but mostly cottonwood saplings in this area. The single clump of red osier dogwood found exposed was nearly completely utilized.

The animal had, some days previous, been up to the new ROW and had traveled along it for a distance of about 50 m just south of the Mountain Creek Bridge. Most recent sign was nearer the confluence of Mountain Creek with the Beaver River.

The snow in this area was very deep, about 125 cm+, with a 12 mm ice crust in the open areas (from the rain), and with that crust reduced to 4 mm under the tree canopy. Virtually all deciduous undergrowth in this area (very lush in summer) was under the snow, except near the boles of some of the larger trees where snow depth in the qamaniq (see Formozov 1946) was less than 35 cm in some cases.

Two moose beds were seen in the vicinity of the NE corner of the camping area. One, under cover of a spruce canopy, had "old tracks" leading in and fresh tracks leading out, suggesting that the animal had waited out the most recent storm at that location. The first three cottonwood saplings encountered were nearly completely demolished: on one, of 42 branches/twigs, all but three had been eaten off to within 6 - 7 cm of the main stem; some were 3 - 4 mm thick at point of browsing.

A fresh bed in the open had been compressed so that the bottom, where the moose was lying, was 90 cm from the surface of the surrounding snow. All moose tracks seen in upland areas here consisted of a furrow made by the animal's body, with deep leg holes. The animal(s) in this area had done some traveling along the Beaver River, where snow depth on the ice was only about 30 cm.

E. In a section of 2.6 km along the new ROW south of the campsite access road, old moose tracks appeared once -- the animal traveling about 100 m along the cleared corridor before going back downslope.

A small amount of browsing on cedar saplings was noted in that area.

18 February 1983

F. Fresh tracks seen in woods above Pusher Station bridge.

G. Cow and calf seen bedded down on access road into Mountain Creek campground, just past bridge.

19 February 1983

H. After the aerial survey, we went to the Stoney Creek area to determine freshness of tracks seen there. A moose had been holed-up in the area for some time, staying mostly at the interface of the conifer-deciduous opening just south of the new Stoney Creek access road. There was no evidence that it had been as far up as the new ROW clearing, but it had been within 100 m. The highest tracks were several days old, and led generally downhill. It was apparent that the animal's daily movements amounted to little more than 50 m -- perhaps much less on some days. Most of its feeding in this area was on the bark of small cedars. One about 12 cm basal diameter had been much used. The animal had also stripped bark and eaten a few twigs from a large alder, had apparently nibbled twigs of a few small spruce and had eaten two willows completely (only basal stems 15 - 18 mm in diameter remaining). Although there were many small hemlocks present, they were apparently untouched -- as were most poplars. An exception for the latter was one large poplar (30+ cm basal diameter) which had fallen; in this case the moose had barked several branches and most of the upper two-thirds of the main stem. I would predict a high degree of incisor wear for moose subsisting

in this manner. This animal was flushed, but not seen, about 150 - 200 m above the highway. It came out of the woods at the bottom end of the new access road and back uphill along the road on our snowshoe tracks. Fresh droppings from this animal were very elongate; although it has not been tested on a scientific basis, Alaskan Native Lore claims elongate pellets are produced by females.

20 February 1983

I. Investigation of sign seen from the air downstream from the Beaver Pit bridge (one observer on each side of the river): Most red osier dogwood on the west side of the river had been browsed, but no fresh tracks were seen within 2 km of the bridge. However, fresh tracks and browsing was seen on the east side of the river in that distance, indicating that there was still a moose present in the area.

15 March 1983

J. One bull moose (antler scars closely observed through 20x spotting scope) seen bedded down in alder/willow patch east of highway about 3 km south of Beaver River bridge; the same area checked on opposite day and animal not present. The snow is very hard-packed in early a.m. and it appears the animals are more mobile now than they were in January and February.

16 March 1983

K. In the early morning, a cow and calf moose seen walking around on top of the snow in the forested area near the turn-off to the Mountain Creek Campground.

L. Fresh moose tracks (cow and calf) down from slide 9 km west of Rogers Pass (lodge), in Illecillewaet drainage.

26 April 1983

M. Tracks of cow and calf seen along the Beaver River at the picnic site near East Gate.

N. Fresh moose tracks seen on mud bars both above and below the Beaver Pit bridge.

27 April 1983

O. Each observer walked about 1 km along the new ROW in opposite directions from the Mountain Creek access road: to the north, one moderately fresh track of an adult-sized animal was followed along the ROW to the new bridge; an absence of snow and poor tracking conditions made it impossible to determine whether the animal went up or down the creek at that point, but it clearly did not cross the bridge.

P. To the south, one pellet group was seen on the ROW and fresh tracks were seen along the river just upstream from the Mountain Creek bridge.

28 April 1983

Q. Bull moose seen bedded down on an oxbow sand bar below the overlook from the TCH south of the Beaver Pit access road.

APPENDIX 4

MOOSE UTILIZATION OF THE PROPOSED NEW RIGHT-OF-WAY, PRE-CLEARING: A SUMMARY OF EVIDENCE.

In June 1982 a series of vegetation plots were sampled along the narrowly cut surveyed center line. The entire length of the Beaver Valley segment, from the Pusher Station bridge to stake No. 530 (approximately 16.2 km) was traversed during this time. The existing rail line was used for access, so it too was covered on foot between Stoney and Mountain Creeks. Proportionately more time was spent, and search for sign was both more extensive and intensive, in the major creek and slide areas where wildlife sign was expected to be most concentrated. A summary of observations pertaining to moose is given below (from MacLaren Plansearch 1983a).

Winter Pellet Groups

- Only 20 pellet groups were seen along the entire route, a density of just over 1 per km.
- Given winter defecation rates documented by Franzmann et al. (1976), the above total is the equivalent of about 1.1 moose days' output.
- Six of the 20 groups were judged to be certainly older than one year.
- Of the 14 known or suspected to have been deposited in the previous year, eight (57%) were within 1 km of Mountain Creek and six were actually along that section of the line adjacent to the Mountain Creek campground.
- The only other relative concentration areas were:

  1) in the vicinity of survey stake 400 (four droppings over a distance of about 50 metres). The vegetation attraction in that area, if any, was not evident;
  2) three droppings (2 old) near survey stake 371, which was near the slide area north of Stoney Creek.

- No pellet groups were observed along the existing rail line (Stoney Creek to Mountain Creek; junction of new and old ROW to Pusher Station).

Summer Droppings

- None were seen along either line.

Evidence of Browsing

- Three incidences noted:
  1) moderate to heavy just north of Mountain Creek;
  2) light, south of Mountain Creek campground;
  3) light at Surprise Creek despite an abundance of stems (red osier dogwood and willow).

Distribution of Important Browse Species

Relative abundance scale of 1 - 4 for vegetation plots observed, where one is lowest (see MacLaren Plansearch 1983a).

Cornus stolonifera (red osier dogwood) - two occurrences (abundances 2,2) in 38 plots south of Mountain Creek; seven occurrences (4, 2, 1, 4, 1, 3, 4) in 11 plots at or north of Mountain Creek.
Salix sp (willow) - three occurrences in 49 plots, all at or north of Mountain Creek (1, 2, 2).

Populus sp (poplars) - five occurrences (1, 1, 1, 1, 1) in the 38 plots south of Mountain Creek; seven occurences (1, 1, 2, 2, 1, 2, 2) in 11 plots at or north of Mountain Creek.

Other Evidence

- Fresh tracks of adult and small calf in riverside willow thicket at stake #30, i.e., near north end of proposed ROW.

Summary: Most sign and winter browsing opportunity occurred at or north of Mountain Creek. Summer feeding opportunity occurred at several locations, especially the drainage gullies and slide areas, but no summer droppings were seen and recent tracks were found only along the lower Beaver River north of Mountain Creek.

APPENDIX 5

RECOMMENDATIONS FOR REDUCING DIRECT
KILL OF MOOSE BY TRAINS IN WINTER
(FROM RAUSCH 1956).

This study of moose behavior and activities suggested several possible means for temporarily removing moose from the tracks or otherwise reducing the kill. These are as follows:

1. Operate trains through the critical area between Houston and Talkeetna during daylight hours, whenever it is economically feasible.

2. Manipulate headlights and horn to frighten the moose from the tracks.

3. Operate trains at reduced speeds through critical areas.

4. Spread the snow berm as soon as possible after the initial plowing operation.

1. Daylight train operations - Moose habits, as discussed in another section of this report, indicate that trains operated in the daytime will probably kill significantly fewer moose than those operated at night. However, the economics of train operation must be taken into consideration in evaluating this proposal.

2. The horn blast - It is standard procedure to sound the trains horn when a moose or any other animal is sighted on the tracks. The sound of the horn does frighten moose; however, this fear, usually expressed in action, does not always have the desired effect of removing the moose from the track. Generally, the moose will attempt to leave the right-of-way immediately following the first horn blast. However, should the moose encounter deep snow it will immediately return to the tracks.

The tendency of moose to leave the tracks at the sound of the initial horn blast has a definite moose-saving possibility. The following examples, taken from the investigator's field notes,

illustrate the technique that can partially alleviate the moose kill and avoid unnecessary delay of trains. On January 6, 1956, while riding a northbound night freight (No. 26) from Anchorage to Curry, 17 moose were encountered on the tracks; two were killed. The engineer, after sighting a moose on the tracks did not sound the train's horn until within 50 to 150 feet of the moose. In all cases, except the two previously mentioned instances, the moose jumped from the tracks. Since the engine was very close to the moose, the moose did not have an opportunity to re-enter the tracks until after the train had passed.

To further illustrate the value of this technique, the following example, taken from field notes, is presented. On February 13, 1956, while riding No. 26 between Anchorage and Curry, eleven moose were encountered on the tracks; eight were killed. The engineer sounded the train's horn as soon as he sighted a moose. Usually, the moose would jump from the tracks, but would have time to re-enter the tracks before the engine had passed. Continued horn blowing irritated the moose, and although they usually attempted to outrun the train, one bull did turn and charge it. The train was pulling over 2,000 tons at about 40 - 50 mph. Stopping safely in less than one quarter of a mile was not possible, and the moose which attempted to outrun the train could not be avoided. In addition to killing eight moose the train was three hours late at Curry.

This technique of timing the horn blast with the train's speed is not a permanent solution to the railroad moose problem, nor does it work all the time, but it will reduce moose fatalities and help prevent unnecessary train delays.

3. Speed - Train control is dependent upon speed and momentum. A freight train pulling over 2,000 tons cannot safely stop within a quarter of a mile. Train control and speed appear to determine moose fate in some areas.

From Anchorage to Wasilla the Alaska Railroad winds along a narrow bench between Knik Arm of the Cook Inlet and the foothills of the Chugach Mountains. This results in a great number of curves and turns on the railroad, and a maximum speed of 30 mph. Freight trains seldom attain this maximum speed.

Aerial surveys and personal observations indicate that there are more moose per mile of track through Anchorage to Wasilla area than on any other segment of the railroad. However, only 22 moose were reported killed on this 45 mile segment of the railroad. In addition to the favorable browse and local climatological conditions discussed in another section of this report, the moose have more time to get off the track because of the slower maximum speeds and greater train control. Snow depths between Anchorage and Eklutna and Pittman to Willow are not directly comparable, but they are similar. The snow from Anchorage to Eklutna was deep enough to cause moose considerable trouble. Six moose were reported killed on this segment, while 22 moose were reported killed on the shorter Pittman-Willow segment. The moose population between Anchorage and Eklutna was very great, whereas, the apparent winter population from Pittman to Willow was low. Aside from the previously indicated differences, the major difference between these two segments seems to be speed and train control. The maximum speed permitted from Anchorage to Eklutna is 30 mph; the maximum permitted speed from Pittman to Willow is 49 mph.

The portion of track from Mile Post 195-225 accounted for 75 reported moose kills between February 9, 1956, and March 10, 1956. During this period 115 kills were reported between Mile Posts 4 and 420. Thus, 65% of this kill occurred on 7% of the kill area.

A slow order on the 30 miles of track from Mile Post 195 to 225 would probably have saved many moose and considerable expense to the railroad, because it was on this segment of the track that a moose caused an expensive derailment.

4. Snow Removal - This past season's study indicates that moose gather on the tracks in great numbers during and immediately following major snow storms. At least 50 moose were killed during the December 30, 1955 - January 1, 1956, snow storm. Those moose killed during the snow storm probably cannot be avoided. However, some of those killed following the initial snow removal operation may be saved by spreading the wall of snow adjacent to the tracks as soon as possible in the critical areas. The snow wall, or berm, adjacent to the tracks discourages moose from leaving the right-of-way once they have entered it. Removal of this obstacle allows the moose to leave the tracks if they are so inclined. Interviews with several longtime engineers indicate that this snow spreading operation saves many moose.

The temporary expedients discussed in this section will not solve the moose-railroad problem, but they may partially alleviate the situation until a more permanent solution has been devised.

APPENDIX 6

OBSERVATIONS OF MAMMAL USE
OF THE NEWLY CLEARED CPR RIGHT OF WAY (ROW),
8 DECEMBER 1982, IN THE STONEY CREEK AREA OF
GLACIER NATIONAL PARK, B.C.

During winter 1982-83 field studies in the Glacier National Park area, snow conditions were suitable for adequately monitoring mammal activity only on 8 December. During the remaining months, rain-on-snow or temperature crusting greatly hampered tracking efforts.

Snow was sufficiently soft on 8 December to register tracks of mouse/vole sized animals, and tracks had been accumulating since a 9 cm snowfall on 4 December (data from Atmospheric Environment Service).

The observer snowshoed along the new ROW from the new access road north to the first deciduous slide area, where moose tracks had been observed previously from the air. All other tracks seen in that section, a distance of about 1.4 km, were identified and direction of travel noted. In addition to the moose tracks, which proved to have been made by two animals (as described in Appendix 3), the following were seen.

Small Rodents - tracks of mouse/vole-sized animals crossed the ROW twice and were seen along the ROW at three other locations. In all cases the animals had been on top of the snow for only short distances, the beginnings and ends of the tracks occurring as tunnels.

Red Squirrel - four "crossing areas", three of which occurred as trails on which the animals had passed more than once in both directions. A minimum of four individuals was believed represented by these crossings.

Snowshoe Hare - seven crossing areas, as above, i.e. most involving several crossings per area. At least seven animals were represented, and two had traveled along the cleared ROW for 50 - 75 m.

Marten - eleven marten crossings, mostly along drainage gullies. The number of animals represented is not known, but judging from the number of occasions on which both east-bound and west-bound tracks

were close together (suggesting one animal had gone over and back), the maximum was five. Most had crossed the ROW at approximately right angles, but one followed the cleared corridor for about 100 m.

Weasel - two crossings, one in each direction but far enough apart to possibly represent two individuals.

Wolverine - two excursions from the Beaver Valley up to the east edge of the cleared ROW, but did not cross in either case.

APPENDIX 7

OBSERVATIONS OF MAMMALS AND SIGN, OTHER THAN MOOSE,
GLACIER NATIONAL PARK AND VICINITY, B.C.
ON MACLAREN PLANSEARCH FIELD TRIPS, WINTER 1982-1983

NOTE: These are incidental sightings made during ground studies and associated travel. Additional records for some species also appear in the flight reports for this time period (Appendix 2). Scientific names follow Banfield (1974).

. Snowshoe Hare (Lepus americanus)

8 December - minimum of seven "crossing areas" on new ROW north of Stoney Creek (see Appendix 6), and several tracks seen in second-growth conifer area on Stoney Creek fan;
13 January - three crossing areas along Pusher Station road;
18 February and 15 March - two crossings along Pusher Station road.

. Columbia Ground Squirrel (Spermophilus columbianus)

26 April - two seen along cleared TCH right-of-way near East Gate and six more in horse pasture area south of East Gate.

. Red Squirrel (Tamiasciurus hudsonicus)

8 December - minimum of four along new ROW north of Stoney Creek (Appendix 6), and a few tracks seen among small conifers in Stoney Creek fan area;
13 January - sign common in Mountain Creek campground area;
15 March - one seen along Beaver Pit road.

. Beaver (Castor canadensis)

13 January - a beaver had been active along a side channel of Mountain Creek, traveling through and feeding among the willow and alder patches along the creek (both species utilized). The animal was undoubtedly "in trouble"; it had been feeding on small twigs on-the-spot, not bothering to take food back to the stream.

20 February - below the Beaver Pit bridge, beavers have been out of the water regularly on both sides of the river. Evidence of use of alder and hemlock was seen on shore, and a cedar which had fallen into the river had been limbed.

. Red-backed Vole (Clethrionomys gapperi)

26 April - one seen beside the Beaver River at the picnic site north of East Gate.

. Porcupine (Erithizon dorsatum)

13 January - one seen dead on the TCH 3 km west of the west boundary of Mount Revelstoke National Park.

. Coyote (Canis latrans)

13 January - tracks of one in the Beaver Pit bridge area; tracks of one along the Mountain Creek access road but none west of the Beaver River in that area;
18 February - tracks beside Beaver River across from Stoney Creek;
20 February - tracks of at least two animals along Beaver River and various sloughs and beaver systems below the Beaver Pit bridge. It appears they were hunting beavers, since all beaver haul outs had been closely investigated;
15 March - tracks: one animal, at Beaver Pit bridge, one along Pusher Station road, and one at East Gate;
16 March - one animal seen along road near east boundary; two, apparently a mated pair, seen sunning on a slide path about 9 km west of Rogers Pass (lodge).

26 - 27 April - tracks: Pusher Station road; river bar near Mountain Creek campground; beside river opposite Stoney Creek.

. Red Fox (Vulpes fulva)

27 April - a small canid track was seen on a mudbar along the Beaver River across from the mouth of Stoney Creek. It was significantly smaller than coyote tracks at the same location, and this probably constitutes another fox record for the area (see Van Tigham et al. 1982).

. Black Bear (Ursus americanus)

27 April - fresh track of small individual in snow along Stoney Creek Station road, near present rail line.

. Grizzly Bear (Ursus arctos)

27 April - track of fairly large animal along ROW just north of Mountain Creek bridge. It had travelled along the ROW north for a short distance, then went into the woods and down into the Beaver Valley north of Mountain Creek.

. Marten (Martes americana)

6 December - up to five individuals had crossed the new ROW a total of eleven times north of Stoney Creek (see Appendix 6); there were also many tracks on the Stoney Creek fan area. One of the CP Rail engineers had seen a marten along the existing rail line sometime prior to this date;

13 January - tracks of one in Beaver Pit bridge area; the rain-on-snow weather prior to and during the January study period resulted in surface-crusting which negatively influenced track counts of smaller mammals. Marten sign, representing at least two individuals, was seen in the vicinity of the new ROW in the Mountain Creek

area. In one case a very fresh dropping was found on the ROW, but no tracks were present. One set of tracks also seen along the Pusher Station road on this day.

20 February - fresh tracks across an open swamp system, west side of Beaver River below. Beaver Pit bridge, and another set along the east side of the river in that area.

27 April - light-coloured animal crushed on TCH about 0.5 km north of Glacier Park lodge; one fresh dropping on new ROW south of Mountain Creek campground.

. Weasel (presumably mostly Mustela erminea)

8 December - tracks at two locations along the new ROW north of Stoney Creek, and a few tracks in Stoney Creek fan area; one track at Beaver Pit bridge;

13 January - again, tracks of one in Beaver Pit bridge area; track of at least two in Mountain Creek campground area;

18 February - tracks roadside, west of Rogers Pass;

20 February - tracks of one along beaver slough on west side of river below Beaver Pit bridge.

. Mink (Mustela vison)

13 January - clear set of tracks found under the new ROW bridge across Mountain Creek. Judging from the size of the tracks, the animal was a mature male. It had come downstream to the bridge from an undetermined distance, continued downstream about 70 m along the edge of the creek (moving down to stretches of open water on three occasions in that distance), then went under an over-hanging bank. No further tracks were seen from that point to the confluence with the Beaver River.

20 February - tracks coming out of the water on east side of Beaver River about 300 m below the Beaver Pit bridge;

27 April - distinct tracks in mud along Beaver River near mouth of beaver system south of East Gate.

. Wolverine (Gulo gulo)

8 December - tracks all over Stoney Creek fan area and up to new ROW just south of the Stoney Creek bridge and north of the bridge about 1 km. A fresh scat deposited by that animal contained only porcupine hair and quills, mostly the latter;
20 February - tracks along east side of river below Beaver Pit bridge.

. Deer sp

27 April - tracks, probably from the previous fall, seen on river bars both above and below Beaver Pit bridge.

. Elk (Cervus canadensis)

8 December - concerted search in Stoney Creek fan area failed to reveal any recent sign of this species;
27 April - three old pellet groups seen in wet area east of the river and south of East Gate;
28 April - three elk, apparently having just crossed the Beaver River below the highway bridge, seen at bottom end of Stoney Creek fan; their behaviour was nervous and flighty, and the reason for that was not apparent although it may have been related to a recent highway crossing.

. Mountain Goat (Oreamnos americanus)

27 April - one nanny and one yearling billy, not together, seen on cliffs above Tupper snowsheds;
28 April - two unclassified adults on cliffs north of west portal, Connaught Tunnel.

APPENDIX 8

INCIDENTAL OBSERVATIONS OF VERTEBRATES OTHER THAN MAMMALS
DURING WINTER 1982-83 FIELD STUDIES
GLACIER NATIONAL PARK AND VICINITY, B.C.

Note: observations recorded below were obtained during ground studies and associated travel, December 1982 through April 1983. Additional observations of birds, as recorded during aerial surveys during that period, are listed in the flight reports (Appendix 2). Common and scientific names are those approved by the American Ornithologists' Union (1982).

BIRDS

. Canada Goose (Branta canadensis)

26 April - fresh tracks in mud along river near Beaver Pit bridge; two seen flying along river south of East Gate.

. Mallard (Anas platyrhynchos)

26 April - one pair roadside, just east of Revelstoke;
28 April - one pair just upriver from Pusher Station bridge; on beaver pond below overlook at east boundary Glacier National Park (GNP) - three males; west portal area (new long tunnel) - three.

. Green-winged Teal (Anas crecca)

26 April - one pair on artificial pond near Beaver Pit bridge;
28 April - on beaver pond below overlook at East boundary GNP - one pair.

. Common Goldeneye (Bucephala clangula)

26 April - one pair on pond west of East Gate;
28 April - one pair on beaver pond east of Beaver River in Stoney Creek area.

. <u>Bufflehead (Bucephala albeola)</u>

<u>28 April</u> - one male on beaver pond below overlook at east boundary of GNP.

. <u>Red-tailed Hawk (Buteo jamaicensis)</u>

<u>16 March</u> - one light-phase adult near East Gate; one light adult near Mount Revelstoke National Park (MRNP) east boundary; one soaring near west boundary, MRNP;
<u>28 April</u> - one soaring over Flat Creek area.

. <u>Golden Eagle (Aquila chrysaetos)</u>

<u>26 April</u> - one soaring above Tupper snowsheds area.

. <u>Ruffed Grouse (Bonasa umbellus)</u>

<u>13 January</u> - one seen in Mountain Creek campground;
<u>26 April</u> - one drumming downstream from Beaver Pit bridge.

. <u>Ptarmigan sp (presumably Lagopus leucurus)</u>

<u>8 December</u> - tracks of at least three on Stoney Creek fan -- one flushed in thick second-growth conifer, but not seen;
<u>18 February</u> - tracks roadside near west portal area, Connaught Tunnel.

. <u>Northern Flicker (Colaptes auratus)</u>

<u>27 April</u> - East Gate area, one red-shafted phase;
<u>28 April</u> - Stoney Creek area, two red-shafted phase.

. Pileated Woodpecker (Dryocopus pileatus)

13 January - fresh holes in cedar along Beaver Pit road;
19 February - fresh workings on a cedar near Stoney Creek, and freshly made holes in another cedar 75 m downriver from Beaver Pit bridge;
27 April - one seen near pond south of East Gate.

. Hairy Woodpecker (Dendrocopos villosus)

20 February - one female seen downriver from Beaver pit bridge.

. Three-toed Woodpecker (Picoides tridactylus)

8 December - one male along new ROW north of Stoney Creek.

. Tree Swallow (Tachycineta bicolor)

28 April - Stoney Creek fan area, three; Glacier Park lodge, two.

. Gray Jay (Perisoreus canadensis)

18 February - near GNP east boundary, two;
15 March - Rogers Pass (lodge) area, one, one.

. Steller's Jay (Cyanocitta stelleri)

8 December - TCH, Revelstoke to Pusher Station, seven;
13 January - Mountain Creek campground, six;
18 February - near GNP east boundary, five;
19 February - MRNP east boundary, one;
20 February - one pair downriver from Beaver Pit bridge;

15 March - one near east boundary MRNP (highway); GNP west of Rogers Pass, one, one, two; Rogers Pass (lodge area), three, two; East Gate area, one, three;
16 March - Beaver Pit area, one; Beaver bridge to East Gate, one, two, one, one; East Gate to east boundary GNP, two, three; along highway, Glacier Park lodge to west boundary GNP, two, one, two; along highway, MRNP, four, one; west of MRNP, one;
26 April - Rogers Pass area, one; East gate, four.

. Common Raven (Corvus corax)

8 December - TCH, Revelstoke to Pusher Station, seven;
13 January - GNP, west boundary to Glacier lodge, one, one, two;
18 February - Pusher Station road, six; Beaver Valley, two, Rogers Pass to GNP west boundary, one, two, two;
19 February - Revelstoke to MRNP west boundary, one, one, one; MRNP to GNP west boundary, one, three, two; GNP west boundary to Glacier Park lodge, one, one;
20 February - west portal area, one; East Gate, one, two, one; Beaver River highway bridge;
15 March - Pusher Station area, one, four;
16 March - East Gate area, one, three; Mountain Creek, one; Pusher Station area, nine; along highway in GNP, lodge to west boundary, one, one, two, one; along highway, MRNP, one, two; west of MRNP, one eating a road-killed bird larger than a siskin;
26 April - near west boundary GNP, one;
28 April - Flat Creek area, two.

. American Crow (Corvus brachyrhynchos)

15 March - along highway, near east boundary of MRNP, two, one, one; GNP west of Rogers Pass, one, one, two; Pusher Station area, one;
16 March - Tupper snowsheds area, one; along highway, East Gate to Mountain Creek, one, three; East boundary area, eight; Glacier Park lodge area, one; 7 km west of lodge, one; near west boundary MRNP, two; west of MRNP, one;

26 April - Rogers Pass area, one; East Gate area, two, three, two; Beaver River bridge area, ten.

. Clark's Nutcracker (Nucifraga columbiana)

8 December - TCH near GNP east boundary, two;
13 January - Pusher Station area, one; Mountain Creek campground, one, two;
16 March - Beaver Pit area, two; near Revelstoke (TCH), one;
26 April - east boundary GNP, one.

. Black-capped Chickadee (Parus atricapillus)

20 February - Downriver from Beaver Pit bridge, one pair;
15 March - Beaver Pit road, one, one.

. Red-breasted Nuthatch (Sitta canadensis)

13 January - Mountain Creek campground, one heard;
19 February - Stoney Creek area, one heard;
20 February - one downriver from Beaver Pit bridge;
16 March - Pusher Station road, one heard;
27 April - Mountain Creek campground, one; beaver pond area south of East Gate, one heard.

. American Dipper (Cinclus mexicanus)

18 February - Pusher Station road, one just below bridge;
20 February - Beaver Pit bridge area, one.

. Winter Wren (Troglodytes troglodytes)

27 April - Mountain Creek campground, one; beaver pond south of East Gate, one.

. American Robin (Turdus migratorius)

16 March - along highway, MRNP, one, one; Along highway, west boundary MRNP to Revelstoke, one;
26 April - one near Glacier Park lodge; picnic site east of East Gate, one; Beaver Pit road, one;
27 April - 1 km west of Glacier Park lodge, one;
28 April - Pusher Station Road, one; East Gate area, one.

. Varied Thrush (Ixoreus naevius)

20 February - GNP east boundary area, glimpsed bird crossing highway, believed to be this species;
15 March - one seen roadside just east of Revelstoke, one; near west gate of MRNP, five; near west gate GNP, two; Pusher Station area, one, two, two, three; Beaver Pit road, two; Glacier Park lodge, one;
16 March - at least two singing in Beaver Pit area; one singing and two seen along Pusher Station road; along highway, MRNP, one, one, one dead, two; west of MRNP, one;
26 April - one along Beaver Pit road;
28 April - Pusher Station road, several singing; lodge area, at least two singing.

. Golden-crowned Kinglet (Regulus satrapa)

13 January - Mountain Creek campground, one;
27 April - beaver pond area south of East Gate, one.

. Ruby-crowned Kinglet (Regulus calendula)

28 April - East Gate area, one singing.

. Water Pipit (Anthus spinoletta)

26 April - 20 passerines seen in flight near East Gate were almost certainly this species.

. European Starling (Sturnus vulgaris)

15 March - Pusher Station area, three;
26 April - picnic site north of East Gate, two;
28 April - Stoney Creek area, one.

. Red-winged Blackbird (Agelaius phoeniceus)

16 March - TCH near Beaver Pit turnoff, three males.

. Evening Grosbeak (Coecothraustes vespertinus)

8 December - TCH near east boundary GNP, six;
16 March - same location; ten.

. Purple Finch (Carpodacus purpureus)

28 April - Pusher Station road, one female.

. Pine Grosbeak (Pinicola enucleator)

8 December - Pusher Station area, eight.

. Rosy Finch (Leucosticte arctoa)

15 - 16 March - TCH area near Tupper snowsheds, 100+.

. Pine Siskin (Carduelis pinus)

8 December - TCH, Revelstoke to Pusher Station, 150+ 15, 50+;

13 January - TCH, MRNP, 40+, 100+, 35+; TCH, GNP west boundary to Glacier lodge, 150+, 15, 50+;
18 February - Pusher Station road, six, one; Rogers Pass area, 100+, 20;
19 February - Revelstoke to MRNP west boundary, six, two, seven, fourteen, eight, three; MRNP to GNP west boundary, three, two, two, four live and one dead, 30+, 20+, 10, 20, 15, 5, 35+, 10, 6, 25; GNP west boundary to lodge, 10+, 50+, 4, 25, 5, 5, 4;
20 February - MRNP east boundary, four; downriver from Beaver Pit bridge, 50+, 75+, two, 100+;
16 March - along highway in GNP east of Rogers Pass, two, four, two, 25+, 15+, three, six, 12; East Gate to east boundary GNP, along highway, 5, 20+, 15, 5; East boundary to Pusher Station, 30+, 3; lodge to west boundary, GNP, 7, 1, 6, 2, 3, 10, 2; along highway, MRNP, eight, 1 live and two dead, 3, 15; West of MRNP, 3, 3;
28 April - Pusher Station road, four.

. Red Crossbill (Loxia curvirostra)

13 January - near MRNP west boundary (TCH), nine;
15 March - one female dead on highway near west boundary GNP, live male and two females nearby; three dead on highway just east of Rogers Pass;
16 March - along highway in GNP, Rogers Pass to East Gate, 1, 3, 1, 2; east boundary area, 2, 6;
26 April - Beaver Pit road area, one male and two females;
28 April - East Gate area, four.

. White-winged Crossbill (Loxia leucoptera)

19 February - Flat Creek area, one pair.

. Dark-eyed Junco (Junco hyemalis)

16 March - TCH near GNP east boundary, one.

NOTE: The siskins and to a lesser extent the crossbills were gathered along the highway during much of the winter, especially in December and January, and many were being killed on the road. In many cases ravens were in attendance near vulnerable groups, acting as "morticians".

FISH

26 April - Beaver Pit area, backwater slough upstream from bridge, a school of 75+ small (20 mm) salmonoid fry (parr marks seen). Presumed to be whitefish.

APPENDIX 9

CLIMATE FEATURES IN WINTERS 1981-82 and 1982-83 IN COMPARISON
TO THE 30-YEAR "NORMAL"
FROM WEATHER STATION OF GLACIER (ROGERS PASS), BRITISH COLUMBIA

APPENDIX 9

Climate[a] features in Winters 1981-82 and 1982-83 in comparison to the 30-year "normal", from weather station of Glacier (Rogers Pass), British Columbia.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Mean Daily Temp (°C)							
Normal	2	-4	-9	-11	-7	-4	1
1981-82	2	-2	-10	-12	-9	-4	-1
1982-83	1	-8	-9	-6	-4	-1	-
No. Days with Frost							
Normal	21	30	31	31	28	31	26
1981-82	20	27	31	31	28	31	29
1982-83	25	30	31	31	28	31	-
Total Ppt. (mm)							
Normal	134	169	205	194	165	126	90
1981-82	139	91	232	351	221	145	63
1982-83	86	92	136	261	148	82	-
Snowfall (cm)							
Normal	59	161	203	194	165	119	59
1981-82	11	73	232	351	234	145	73
1982-83	25	92	136	253	131	53	-
No. Days with Meas. ppt.							
Normal	17	17	22	18	16	16	15
1981-82	22	17	25	27	21	19	11
1982-83	17	16	21	23	23	19	-

[a]Monthly data, rounded to nearest whole figures (°C, mm, cm), are from Environment Canada (Atmospheric Environment Service), Vancouver office; Normals from "Canadian Normals" as published by the same source, and referring to the years 1941-1970.